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CCUS IN THE INDIAN CEMENT INDUSTRY POLICY & FINANCING FRAMEWORKS

Global Cement and Concrete Association

CARBON CAPTURE, UTILIZATION & STORAGE
ACCELERATING CCUS TOGETHER
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

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1.0 INTRODUCTION

1.1 Introduction

In the first part of this series *(Outcome 1)*, we conducted a review of cement-sector emission clusters and onshore and offshore geological storage resources in India. This allowed us to identify potential sites for transporting and permanently storing CO_2 emissions from cement facilities. Additionally, we analysed the feasibility of establishing CO_2 hubs in key locations.

Building upon this technical foundation, this second part (Outcome 2) will focus on examining the policy, legal, and regulatory (PLR) frameworks required to support carbon capture, utilisation and storage (CCUS) deployment. By highlighting successful models from other jurisdictions, we aim to provide recommendations that unlock barriers to CCUS deployment in India and accelerate opportunities to establish the clusters identified in the Outcome 1 report.

1.2 Importance of policy, legal and financing issues for CCUS deployment

Creating an effective legal and regulatory framework is essential for the advancement and implementation of CCUS technologies. Such a framework serves multiple crucial functions: it clarifies operator liabilities, fosters high standards, promotes investment, and instils public confidence by offering a structured approach to addressing and remediating any potential harm resulting from CCUS activities. Additionally, it provides clear guidelines for regulators, delineating their responsibilities and recourse powers when necessary.

Furthermore, the policy landscape plays a pivotal role in overcoming challenges with commercial viability associated with CO_2 storage. Essentially, policy incentives can be employed to internalise the cost of CO_2, ensuring that low-carbon alternatives become more economically attractive than their high-carbon counterparts. This approach drives demand for emission abatement technologies and allows CCUS applications to become financially viable. Policy instruments facilitating the creation of economic value from CCUS include emission trading systems (ETS), carbon taxes, certificates, grants, and subsidies (both direct and indirect), and regulatory mechanisms mandating the phased reduction of emissions.

1.3 About this report

This report evaluates the current status of policies, regulations, legal frameworks and financial support crucial for accelerating the deployment of CCUS technologies, and provides a comprehensive comparison with various approaches followed in selected international jurisdictions. Beyond the analysis, the report also provides actionable recommendations to overcome barriers to the expansion of CCUS initiatives.

In addition, the report aims to identify opportunities for information exchange, international collaboration and unlocking the commercial finance vital for CCUS deployment in India.

A summary of the gap analysis performed, together with recommendations and potential actions, are presented in Section 2 of the report, followed by an in-depth discussion of the status of CCUS in India (Section 3), including a summary in Table 2. The relevant policy, legal and regulatory aspects to CCUS mentioned above are discussed in Section 4 of the report. Opportunities for global collaboration on CCUS, knowledge-sharing and potential funding opportunities are included in Section 5.

2.0 SUMMARY OF GAP ANALYSIS AND RECOMMENDATIONS

Table 1 presents a gap analysis and provides recommendations regarding policy, legal, and regulatory frameworks. The gap analysis aims to pinpoint areas where current frameworks are either underdeveloped or lacking compared to global best practices. By identifying these gaps, the recommendations highlight priority areas where the government should concentrate efforts to strengthen and enhance frameworks.

In the table:

- 'Partially developed' indicates progress in developing a policy, legal, and regulatory framework, but further advancement is needed, as it is not yet as comprehensive as global best practice examples.
- 'Needs to be developed' indicates a significant gap or that a particular policy, legal, and regulatory framework is currently at a very early stage.

Table 1: Policy gaps and recommendations

POLICY STATUS	GAPS	OPTIONS FOR ACCELERATION OF CCUS	RATIONALE	LINK TO DETAILED DISCUSSION IN THIS REPORT
STRATEGIC SIGNALLING				
STRATEGY, INSTITUTIONAL STRENGTH AND GOVERNMENT SUPPORT				

Partially developed	• The government has not released a national CCUS strategy or long-term targets for CO_2 storage.	• Continue support for the following:
		  • Ministry of Environment, Forest, and Climate Change.
		  • India's Net Zero by 2070 Policy.
		• Seek to develop a CCUS strategy to demonstrate government's long-term commitment to CCUS.
			• India has an opportunity to coordinate national CCUS policy around the 2022 Energy Conservation (Amendment) Act, thereby demonstrating political commitment, and encouraging private sector investment. Additionally, integrating CCUS policy with carbon market legislation could ensure consistent treatment of emissions when CCUS is used to meet greenhouse gas reduction obligations.	3.1 Strategy
				3.2.7 R&D Centres in India supporting CCUS
				3.2.8 Department for Science and Technology
				3.2.9 Supporting Institutions
				4.1 Strategy for CCUS

PUBLIC ACCEPTANCE				
Needs to be developed	• The general public is perceived to be largely unaware of the benefits of CCUS. • Environmental Impact Assessments require public consultation on project impacts.	• The National Centres of Excellence (NCOE) in Carbon Capture and Utilisation in Bombay and Bengaluru could support the dissemination of CCUS knowledge to the public to raise profile. • This could include expanding the industry/CCUS expert workshops that the NCOEs are conducting in collaboration with the DST and Niti Aayog. These workshops currently focus on understanding gaps in the CCUS environment but could be broadened to include sessions dedicated to knowledge sharing and raising awareness.	• Experience in other jurisdictions indicates that involving the community in a development reduces the likelihood of issues or delays due to public opposition. National centres of excellence, which have credibility in this area, could serve as effective conduits for disseminating information and knowledge to the broader community.	4.3.6 Issues of public acceptance

POLICY STATUS	GAPS	OPTIONS FOR ACCELERATION OF CCUS	RATIONALE	LINK TO DETAILED DISCUSSION IN THIS REPORT
LEGAL AND REGULATORY ISSUES				
Needs to be developed	• There is currently no legal and regulatory framework in place that governs CCUS activities in India.	• The Indian government should evaluate different legal and regulatory frameworks for CCUS. Options include creating a new standalone framework, amending existing laws, adopting project-specific measures, or other streamlined approaches. Each option has its advantages and disadvantages. The chosen framework should align best with India's policy, legal, and regulatory environment.	• The absence of a legal and regulatory framework to oversee CCUS activities can significantly increase the risk of operational issues and potential CO_2 leakage from geological storage sites. Such a framework is also essential for ensuring consistency in approach to permitting and regulation across projects.	3.3 Legal and Regulatory elements 4.2 Laws and regulations to ensure safety and integrity of CCUS 7.1 Existing regulations relevant to the cement industry
CARBON PRICING				
Partially developed	• While a formal market mechanism does not exist yet, there are signs that the government intends to set up a domestic market. Ensuring that CCUS is incentivised is essential.	• Continue support for the Indian central government's passage of the law in 2022, that authorises the central government to set up a domestic carbon credits trading scheme. (Errol Pinto, 2022; Errol Pinto and Global CCS Institute, 2022).	• The establishment of a formal carbon market will ensure a financial incentive for CCUS deployment, encouraging emitters to invest in climate mitigation technologies rather than emitting freely.	3.2.1 Amendment to the Energy Conservation Bill 3.2.2 Global Voluntary Carbon Markets 4.3.1 Carbon Pricing
SPECIFIC INCENTIVES				
FISCAL INCENTIVES				
Needs to be developed	• Carbon pricing is not regulated through a formal mechanism. • There is currently no carbon tax credit scheme in place. Other tax incentives are available. • No formal fiscal incentive policy is in place that supports CCUS or action on climate change that could be broadened to support CCUS.	• Regulate carbon pricing through a formal market mechanism. Collaboration between the government and stakeholders such as the Carbon Markets Associations of India could expedite market development. • Supplement any proposed future carbon taxes with strong fiscal incentive policies such as tax credits. • Investigate a "Book and Claim" system for the cement industry.	• To address the gap in carbon pricing regulation, where no formal market mechanism exists, the government could establish fiscal incentives for CCUS, such as tax credits, loan guarantees, etc. • Additionally, supplementing potential future carbon taxes with tax credits and other fiscal incentives for CCUS would encourage private sector investment in project development. • The foundation of a "Book and Claim" system represents real decarbonisation across the value chain that includes Scope 3 emissions. This will enable hard-to-abate industries to "book" certificates that could be "claimed" by consumers of their products. This is particularly helpful in countries where there is no formal ETS.	3.2.3 Book and Claim 4.3.2 Specific incentives
PUBLIC FINANCE				
Needs to be developed	• India does not have a formal public finance policy in place that supports CCUS.	• Support CCUS through a dedicated grant or loan program. • Augment private sector support for R&D through fiscal incentives or public finance.	• Public finance programmes could be established to support the deployment of CCUS. While DST has offered some small loans, these primarily target innovation and research rather than project deployment, and they are insufficient in scale to develop commercial projects.	3.2.6 Proposed Carbon Capture Finance Corporation 5.2 International financing mechanisms

POLICY STATUS	GAPS	OPTIONS FOR ACCELERATION OF CCUS	RATIONALE	LINK TO DETAILED DISCUSSION IN THIS REPORT
DEMAND CREATION				

Needs to be developed	• India co-chairs the Industrial Deep Decarbonization Initiative (IDDI) which is developing standards for low carbon and near-zero cement and concrete.
	• Currently, there are no established targets for reduction of the embodied carbon emissions in cement products.
	• However, India has pledged to adopt green procurement principles as part of the IDDI, and aims to develop a set of targets for 2030.
	• There does not appear to be any legislation specifically regarding central government procurement. In this regard, in 2018, a Task Force on Sustainable Public Procurement was established. Public procurement in India has been estimated to constitute about 30 per cent of GDP. Because there is no centralised green public procurement program, there are no estimates of the extent or impact of green public procurement.
		• Adopt low carbon and near-zero cement/concrete definitions recognising the wide range of concrete products and incentivising all decarbonisation levers.
		• Targets for emissions reduction compared with definitions/ references/ benchmarks should be:
		  • Stretching and provide the long-term certainty needed to deliver the demand signal for the industry to decarbonise.
		  • Realistic to ensure customers can find suppliers.
		  • Stimulate demand for low-carbon and near-zero cement and concrete products through public procurement policy.
		• Focus should be placed on the development of central government green/sustainable procurement legislation.
			• Appropriate policies will drive demand for low-carbon and near-zero cement/concrete in India. Given the substantial purchasing demand for cement/ concrete by the public sector, implementing guidelines or standards in this area appears to be an effective way to stimulate demand.
			• A focus on green/sustainable public procurement will enable government to measure the impact of these practices on decarbonisation efforts and will stimulate acceleration of green procurement in India.
				4.3.3 Demand creation for low-carbon and near-zero materials

RENEWABLE ENERGY SUPPORT				
Needs to be developed	• Promising renewable energy initiatives are underway, particularly in solar and wind, with capacity having quadrupled since 2015. However, the transition needs to accelerate to meet net-zero ambitions. • There is a heavy reliance on coal for energy production, with 50% of the country's power expected to come from coal by 2030. India's particularly young coal fleet poses challenges for early retirement. • Fossil fuel subsidies in 2021 were nine times higher than those for renewables, but reduced to four times in 2022.	• Accelerate investment in, and support for, renewables and local net-zero technology manufacturing. • Increase support for renewable energy, and consider support to integrate CCUS with the young fossil-fuelled power plant fleet, to enable continued operation but supporting decarbonisation.	• While renewable energy has made significant progress in India, the ongoing reliance on coal hinders the achievement of net-zero emissions and reduces the effectiveness of CCUS, which may also rely more heavily on fossil fuels as opposed to renewables. Therefore, increased policy attention is needed to accelerate the transition to greener power generation and reduce coal use.	3.2.4 Renewable Purchase Obligation / Renewable Energy Certificates 3.2.5 Renewable Energy Support 4.3.4 Renewable Energy Support
INFRASTRUCTURE DEVELOPMENT				
Needs to be developed	• Limited data available on geological storage locations and their capacity potential. • Limited data available on possible T&S network routes connecting emitters to storage resources. • There is currently no specific government support for developing T&S network infrastructure. • Third party access to shared infrastructure, which could support the development of CCUS hubs, is currently not regulated.	• Seek to expand research on geological storage of CO_2 and access to subsurface data to identify sites with greatest storage potential. • Establish a strategy to map routes connecting storage locations to emitters, which could facilitate the creation of a shared T&S network. • Provide financial support to enable T&S infrastructure development. • Develop a legal and regulatory framework for CO_2 T&S networks.	• Lack of sufficient data on potential CO_2 storage locations and capacity increases uncertainty in planning CCUS projects and identifying possible T&S routes that connect to emitters. • Additionally, the significant upfront investment required for transport and storage infrastructure has led many nations to use public funding to support these capital investments, a practice that India could consider. Given the high barriers to entry and the cost inefficiency of duplicating infrastructure, it is likely that a single provider or operator will operate the T&S infrastructure. It would be prudent to establish regulations to prevent exclusionary or monopolistic behaviour.	4.3.5 Infrastructure development

POLICY STATUS	GAPS	OPTIONS FOR ACCELERATION OF CCUS	RATIONALE	LINK TO DETAILED DISCUSSION IN THIS REPORT
INTERNATIONAL CREDIT TRADING				
Needs to be developed	• Article 6.4 requires detailed guidance and rules to be negotiated and finalised. There is however uncertainty on the inclusion of international credits to meet obligations in the domestic carbon market.	• Clarification should be provided on whether international credits could be used to fulfil part of an emitter's domestic compliance obligations, such as in the EU ETS. • Advocate for environmental integrity and robust accounting standards in the implementation of Article 6.4 mechanisms. • Work with the Article 6 Supervisory body to reflect the position stance of India on the methodologies and procedures for Article 6.4.	• The gap stems from the need for detailed guidance and rules for international trading of carbon credits, and uncertainty regarding their use to meet domestic carbon market obligations. Advocating for environmental integrity and robust accounting standards in the implementation of Article 6.4 mechanisms will ensure that international credits represent genuine emission reductions. Engaging with the Article 6 Supervisory Body to reflect India's stance on methodologies and procedures will further clarify India's position and ensure that its interests are considered in the global carbon market framework.	5.2.5 International Carbon Markets – Article 6
INTERNATIONAL COLLABORATION AND KNOWLEDGE-SHARING				
Needs to be developed	• While India shares information and collaborates through many different vectors, there is an opportunity to consolidate the guidance on CCUS into one source. • India is currently not party to the London Protocol. • India is currently not a participant in some of the major global initiatives in support of CCUS and sustainable cement production. • No policies in place to promote data sharing around CO_2 geological storage resources.	• Continue support for the development of policy in line with the Indian central government's release of a detailed report by *Niti Aayog on CCUS.* • Seek to develop cross-border CO_2 transport policies in compliance with the provisions of the London Protocol (Ian Havercroft, Chris Consoli and Global CCS Institute, 2022). • Seek to participate in global initiatives including the CEM CCUS Initiative, the Carbon Management Challenge and the Cement and Concrete Breakthrough Initiative, to promote information sharing and adoption of best practice. • Create policies that incentivise or obligate oil and gas companies to share data on potential CO_2 geological storage sites. • India could join the Clean Energy Ministerial CCUS Initiative, allowing to draw from the experience of currently fifteen countries across the world as regards CCUS deployment programmes and incentive policy frameworks.	• Supporting the development of policies aligned with Niti Aayog's detailed report on CCUS will help address technical, regulatory, and financial challenges, fostering a conducive environment for investment and innovation in CCUS. • Policies that aim to promote data sharing related to CO_2 storage, could expedite site characterisation and development. Additionally, developing cross-border CO_2 transport policies in compliance with the London Protocol is crucial for engaging in international CO_2 transport and storage projects. • Participation in global initiatives such as the Carbon Management Challenge and the Cement and Concrete Breakthrough Initiative will provide access to cutting-edge research, international funding, and best practices, which could accelerate the adoption of CCUS technologies.	5.1 Domestic stakeholders and collaboration 5.3 Global knowledge-sharing, acceleration and coordination efforts

3.0 POLICY, LEGAL AND REGULATORY ISSUES – STATUS IN INDIA

3.1 Strategy

3.1.1 NITI Aayog's CCUS Report

In December 2022, a few months after the passage of the Energy Conservation Bill, the Government of India released a detailed report on CCUS, titled 'Carbon Capture, Utilisation and Storage (CCUS) – Policy Framework and its Deployment Mechanism in India' (NITI Aayog, Government of India and M. N. Dastur and Company (P) Ltd., 2022). The report was commissioned by NITI Aayog, a think tank affiliated with India's Central Government and was prepared by Dastur, a consulting organisation.

The report is a comprehensive overview of CCUS, sector-wide emissions, carbon capture and utilisation (CCU) technologies, potential for CO_2 storage, and policy frameworks that would be applicable for India to make carbon capture and storage a viable decarbonisation solution. It also discusses state of play in India and internationally with a full range of topics – CO_2 emissions, storage, financing, and technologies. The report also has recommendations on investment and financing mechanisms with guidance on how India can benefit from tax incentives and other approaches used in the United States (NITI Aayog, Government of India and M. N. Dastur and Company (P) Ltd., 2022).

The report highlights the necessity of a hubs and clusters model to scale up CCUS operations. These will include emission-intensive facilities forming capture clusters and CO_2 storage clusters across various geological sequestration sites, oil fields for EOR or CO_2 utilisation projects. The report estimates that India's theoretical storage capacity ranges from 400 to 600 gigatonnes (Gt). For effective capture, the report recommends focusing on the steel, cement, oil and gas, chemicals, and hydrogen industries. It notes that capture costs are lowest for gasification processes and highest for coal-based power plants.

CCUS projects are typically expected to be funded by the Carbon Capture Finance Corporation (CCFC). The CCFC will receive funding from low-cost sovereign or International Green Funds, Carbon Bonds, or Climate Funds. The report proposes two alternative financing mechanisms: reintroducing a clean energy tax on coal at Rs. 400 per tonne of CO_2 starting in April 2026, and financing through bonds and gross budgetary support. It is estimated that US$30.5 billion in bonds with a 9% reinvestment return spread, along with a maximum of 0.5% of the government's spending or Gross Budgetary Support (GBS), can finance 750 Mtpa of CCUS by 2050.

In November 2023, NITI Aayog worked closely with World Bank India and other consultants on a sector-wise CCU policy framework for India. This study is still in progress and the final report has not been published yet. Separately, the think tank also co-hosted a workshop with the World Bank, engaging stakeholders from across the CCUS value chain.

3.1.2 Nationally Determined Contributions

India's initial Nationally Determined Contributions (NDC) outlined three key mitigation components: an emissions intensity target, a non-fossil fuel-based electric power capacity target, and the augmentation of carbon sinks. In its 2022 NDC update, India bolstered both the intensity and non-fossil capacity targets, elevating the intensity target from 33-35% to 45% and the non-fossil capacity target from 40% to 50%. However, the carbon sink target remained unchanged, aiming for a cumulative 2.5-3 $GtCO_2$ carbon sink by 2030.

Although these targets appear more robust on paper, India is poised to surpass them with its existing climate actions. Consequently, the current targets may not spur additional emissions reductions. The prevailing assessment is that much more substantial emissions cuts are required by 2030 to align India with a 1.5-degree Celsius pathway.

The NDC outlines the aspiration to achieve net zero emissions by 2070. In 2022, an introduced net zero emissions bill in the upper house of the Indian Parliament aimed to establish a framework for reaching this goal. However, the bill has not progressed in the legislative process. Notably, being a private member bill rather than a public bill diminishes its chances of receiving parliamentary approval (Climate Action Tracker, 2024a). A private bill is introduced by the Member of Parliament, who is not a minister. Similar to a public bill, a private member's bill goes through the same parliamentary procedure, however the time allotted for deliberation is constrained. A private members bill also has very little chance of passing without MPs' support from the ruling party. It is for these reasons that private bills have a higher chance of not being approved.

India is not one of the 27 countries globally that have acknowledged CCUS in their NDCs. Including CCUS in the NDC would demonstrate India's commitment to CCUS as a key long-term strategy for decarbonisation. This recognition could accelerate efforts across various sectors and open new funding opportunities.

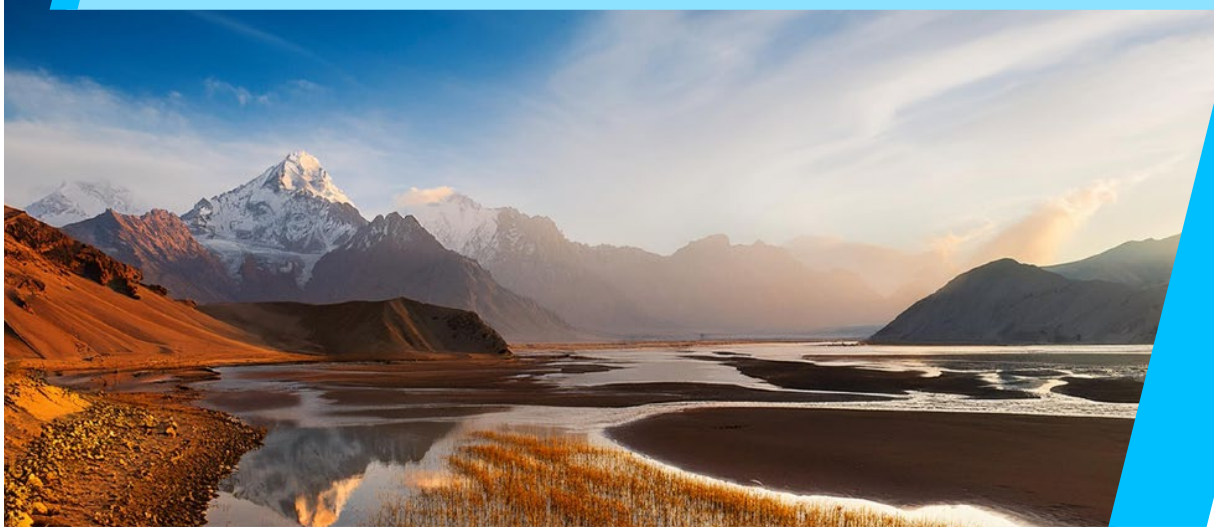
3.2 Incentives

3.2.1 Amendment to the Energy Conservation Bill

In 2022, India amended an energy conservation law originally passed in 2001. The amendment authorised the government to establish a domestic carbon credit trading scheme. The carbon credit certificates will not initially be available for export (Lok Sabha (Lower House) and Parliament of India, 2022; Rajesh Kumar Singh and Bloomberg, 2022). The amendments also allow industries to buy renewable energy directly from producers, enabling price certainty for renewable energy producers.

After the amendment, the government initiated the development of the institutional and regulatory framework for the carbon credit trading scheme. The initial draft notification was released for public consultation in early 2023 and was subsequently revised and issued in June 2023. This notification laid down the groundwork for the institutional setup, including the formation of the National Steering Committee for the Indian Carbon Market, which is responsible for overseeing the scheme.

INDIA IS NOT ONE OF THE 27 COUNTRIES GLOBALLY THAT HAVE ACKNOWLEDGED CCUS IN THEIR NDCS. INCLUDING CCUS IN THE NDC WOULD DEMONSTRATE INDIA'S COMMITMENT TO CCUS AS A KEY LONG-TERM STRATEGY FOR DECARBONISATION.



The Bureau of Energy Efficiency (BEE), in collaboration with the Ministry of Power and the Ministry of Environment, Forest & Climate Change, has been entrusted with the task of establishing the Indian Carbon Market. Under the compliance mechanism, obligated entities will be assigned annual emissions intensity targets for a three-year trajectory period, as notified by the Ministry of Environment, Forest and Climate Change. These targets will be expressed in terms of tCO_2e per unit of product. New targets will be announced every three years to facilitate long-term planning for covered entities. Entities exceeding their emissions intensity targets can earn Carbon Credit Certificates (CCCs) based on the surplus emissions intensity reduction achieved. Conversely, entities failing to meet their targets will be required to surrender or purchase a corresponding number of CCCs to ensure compliance. This will be facilitated through trading among obligated entities on a designated registry or trading platform.

The carbon credit trading scheme (CCTS) adopts a "gate-to-gate" approach, encompassing emissions throughout the entire value chain. This includes both direct emissions from fuel combustion and industrial processes, as well as indirect emissions from electricity and heat consumption. The scheme covers emissions of CO_2 and perfluorocarbons (International Carbon Action Partnership, 2024).

In support of this initiative, The Carbon Market Association of India is a collaborative effort among leading industry professionals dedicated to fostering the growth of a domestic carbon market. Committed to surmounting industry hurdles, the consortium is focused on implementing tangible strategies to facilitate market expansion. By advocating for policies and establishing framework guidelines, the association seeks to bolster industry engagement and participation (Carbon Markets Association of India, no date).

Prior to this amendment, energy consumption has been regulated for energy-intensive sectors through the Performance, Achieve and Trade (PAT) mechanism. Within each sector, plants above a certain specified threshold of energy consumption were identified and called Designated Consumers (DCs). Each of the DCs was assigned an energy intensity reduction target. DCs that were able to achieve energy efficiency gains beyond the target received certified energy savings credits called Energy Saving Certificates (ESCerts) that could be traded on the Indian Energy Exchange (a power trading platform) at a market determined price. DCs unable to meet their targets were required to purchase ESCerts to make up for the shortfall. The policy is mandatory as DCs failing to meet the assigned targets in the above two ways were liable to pay a financial penalty (Oak and Bansal, 2022). The Indian carbon market will succeed the PAT scheme, but will utilise existing monitoring, reporting and verification guidelines and administrative infrastructure. It is expected that a phased transition from the current PAT scheme to the compliance mechanism will begin by the end of 2024.

In December 2023, the government amended the CCTS notification, introducing provisions for the offset mechanism to support non-obligated entities and promote mitigation efforts, encompassing a comprehensive approach for GHG reduction (International Carbon Action Partnership, 2024). While specific information about the inclusion of carbon credits from existing standards in the global voluntary market is not provided, sources indicate that the BEE has engaged in proactive consultations and is contemplating the incorporation of standards that adhere to elevated integrity criteria.

3.2.2 Global Voluntary Carbon Markets

India has played a crucial role in the global voluntary markets, emerging as the world's second-largest contributor of carbon offsets within the voluntary carbon market. As of June 2023, the country boasts over 1,400 projects either registered or in various stages of consideration within the major crediting programs, Verra and Gold Standard (Centre for Science and Environment, 2023). These projects in the voluntary carbon markets span a diverse range, including industrial and agricultural operations, renewable energy, energy efficiency, afforestation, and reforestation. India has successfully issued 278 million credits in the voluntary market, representing a substantial 17% of the global supply, as reported by S&P Global Commodity Insights in 2023 (S&P Global Commodity Insights, 2023).

Based on the current legislative context, it appears uncertain whether India could advance a cement CCUS project under voluntary carbon markets.

3.2.3 Book and Claim

Many companies, especially in the hard-to-abate sector, have embedded carbon emissions in their final product (Scope 3 emissions). 'Book and Claim' is a model currently leveraged by multiple industries, including electricity, aviation, and maritime shipping, among others, that allows clean fuel or materials producers to "book" the emissions savings of a good they have produced

in one place, and customers to "claim" the emissions benefit from these goods for climate disclosures in a different place. Book and Claim is a flexible model for verified information to flow — or chain of custody model that can connect buyers and sellers to decarbonise their value chains together.

Recently, this model has started to be discussed as an opportunity for stimulating demand for near-zero cement and concrete.

3.2.4 Renewable Purchase Obligation / Renewable Energy Certificates

The Renewable Purchase Obligation (RPO) stipulates that every electricity distribution licensee must procure or generate a designated minimum quantity of their electricity needs from Renewable Energy Sources, in accordance with the Indian Electricity Act of 2003. The State Electricity Regulatory Commissions are responsible for determining the minimum RPO for each state (Government of Kerala, no date).

The Renewable Energy Certificate (REC) scheme, introduced by the Indian government in November 2010 and inaugurated in February 2011, aims to assist obligated entities, particularly those in states with a deficit in renewable energy, in meeting their Renewable Purchase Obligation (RPO) targets.

RECs represent the environmental and green attributes of power generated by renewable projects. Obligated entities can utilise RECs to fulfill their RPO targets. Additionally, RECs can be voluntarily purchased. The scheme distinguishes between power generation and green attributes, allowing buyers to acquire only the green attributes to fulfill their renewable energy obligations.

To ensure minimum revenue for project developers and provide price certainty, the scheme incorporates a price band, with floor and ceiling prices. Since its inception in 2010, the price bands have undergone four revisions. In response to low demand during the initial three years of the scheme, the validity period of RECs has been amended twice – first from 365 days to 730 days in July 2013, and to 1,095 days in December 2014. These adjustments were made to address market dynamics and enhance the effectiveness of the REC scheme (RE 100, 2021).

3.2.5 Renewable Energy Support

The Indian Government's Union Budget for 2023 introduces several key initiatives to advance renewable energy. Among these is the Green Hydrogen Mission, which aims to achieve an annual production of 5 million metric tonnes by 2030. The budget also includes substantial capital investments to support energy transition and net-zero goals. It provides viability gap funding for battery storage and outlines a framework for developing pump storage projects. Additionally, funds are allocated to enhance the interstate transmission system to integrate 13 GW of renewable energy from Ladakh. The budget further supports the creation of renewable energy parks and the development of new transmission infrastructure to accommodate 500 GW of renewable capacity by 2030.

3.2.6 Proposed Carbon Capture Finance Corporation

The NITI Aayog report analyses policies in jurisdictions like Australia, Canada, the EU, and the United States, and makes recommendations for the Indian context. The report also discusses CCUS investments and financing mechanisms in detail with a recommendation to the central government to set up a Carbon Capture Finance Corporation (CCFC) that would provide tax and cash credits for CCUS projects in India. The report proposes two mechanisms to fund the CCFC; the first is through a clean energy tax or levy imposed on coal, and the second is through government bonds and budgetary support for CCUS-related subsidies (NITI Aayog, Government of India and M. N. Dastur and Company (P) Ltd., 2022). Three types of projects are discussed with the associated subsidies suggested in Indian Rupees (2022). The numbers below are approximate current equivalents in US Dollars.

a. CO_2 sequestration/storage at US$49/tonne till 2040 and US$36/tonne till 2050.

b. CO_2 EOR at US$36/tonne till 2040 and US$29/tonne till 2050.

c. CO_2 utilisation at US$27/tonne till 2050.

These subsidies may not be sufficient to fully support a CCUS development. It also mentions that CCUS technologies are essential to reduce emissions from India's hard to abate industries. These total emissions are estimated to grow to 2400 Mtpa by 2050 and CCUS will have to increase to about 750 Mtpa to make a meaningful contribution to India's 2050 climate goals. To build this capacity and develop the domestic market, investments in the range of US$100-150 billion (2022 dollars) will be needed over the next 30 years (NITI Aayog et al., 2022; Ruchira Singh & S&P Global Commodity Insights, 2022).

Based on the cost analysis in the Outcome 1 report, the estimated cost of CO_2 capture for a cement plant with a capacity of 0.4 Mtpa is approximately US$130/tonne of CO_2, while for a plant with a capacity of 2.2 Mtpa, the cost is about US$85.3/tonne of CO_2. Given the proposed subsidies, the maximum credit is 2.5 times less than the cost per tonne for a 0.4 Mtpa plant and nearly twice less for a 2.2 Mtpa plant. This suggests that the current subsidies may be insufficient to cover CCUS costs. However, the proposed credit is available until 2050, and costs might decrease over time.

From an international perspective, the proposed tax credit in India is almost half the rate of the US 45Q tax credit for geological storage and EOR. While lower labour costs in India may reduce overall expenses, this presents additional evidence that the proposed tax credit may be insufficient.

3.2.7 R&D Centres in India supporting CCUS

As a leading energy company, Indian Oil Corporation (IOC) invests in R&D related to clean energy technologies. It is currently pursuing pioneering work in CCUS technologies. The centre, in collaboration with other national or international partners, could initiate pilot projects demonstrating the feasibility and benefits of specific CCUS applications (Indian Oil, 2024). IOC is currently working with the Indian Institute of Technology Bombay to analyse storage potential and evaluate CCU potential at a 10 tonnes per day plant. These initiatives could pave the way for larger-scale deployment of CCUS projects.

3.2.8 Department for Science and Technology

The Department for Science and Technology (DST) is at the forefront of advancing research in carbon capture and storage. In a significant move, the department has established a national program dedicated to CO_2 storage research, aimed at supporting carbon capture initiatives and fostering the development of pilot projects. In collaboration with the Department of Biotechnology (DBT), the DST launched a joint call on IC3 (International Carbon Capture Conference) in July 2018. This initiative focuses on collaborative research and development with member countries of Mission Innovation, with the primary goal of identifying and promoting breakthrough technologies in carbon capture and storage.

The DST has played an active role in delivering projects that seek to innovate the CCUS value chain, collaborating with other member countries of the Accelerating CCUS Technologies (ACT) program. As part of this collaboration, the DST has invited proposals to secure funding for projects that have the potential to drive innovation in CCUS. The most recent ACT call specifies a maximum funding of €1 million for up to three projects, all of which will be subject to approval through the DST (Department of Science and Technology, 2024a).

DST also partnered with Clean Energy Transition Partnership (CETP) for a joint call in September 2023 that aims at accelerating the clean energy transition to achieve the goal of climate neutrality by 2050. CETP is a multilateral and strategic partnership of national and regional research, development and innovation (RDI) funding programmes in EU Member States and Associated Countries, co-funded by the European Commission through Horizon Europe.

The CETP includes seven Transition Initiatives (TRIs) addressing a broad range of RDI challenges from discrete technologies to integrated systems for the clean energy transition, as well as several cross-cutting dimensions. TRI3 focuses on providing cleaner technological solutions for storage technologies, hydrogen, renewable fuels, CCU and CCS, contributing to significant CO_2 reduction by 2030 as well as climate neutrality by 2050. (Department of Science and Technology, 2024a).

INDIA RECENTLY ANNOUNCED THE INAUGURATION OF TWO NATIONAL CENTRES OF EXCELLENCE IN CARBON CAPTURE & UTILISATION (NCOE-CCU) AT INDIAN INSTITUTE OF TECHNOLOGY

In 2024, DST has issued a special call for proposals aimed at developing and deploying innovative CCU test beds in the cement sector. The focus is on creating an integrated CCU unit within an industrial setup. This unit should be capable of capturing 1-2 tonnes of CO_2 per day from cement kiln gas, with a retention efficiency of 95-99% and a purity exceeding 95%.

Proposals must be submitted in a consortium mode, involving both academia/researchers and industry. The consortium should be led by faculty members or scientists holding regular positions in recognised academic institutions, publicly funded R&D institutions, or laboratories. Participation from relevant industries, public sector undertakings, or start-ups is mandatory. The consortium must include at least one technology designer and one technology provider. Installation, testing, and validation should be carried out at the collaborating site with the participating industry. The industry partner is required to contribute at least 25% of the total project cost in cash. There is no ceiling on the project costs (Department of Science and Technology, 2024b).

The grant for CCU proposals from DST is still active, since no projects have been funded as yet.

3.2.9 Supporting Institutions

India also recently announced the inauguration of two National Centres of Excellence in Carbon Capture and Utilisation (NCoE-CCU) at the Indian Institute of Technology, Bombay, and Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru. Both are supported by the DST (Ministry of Science and Technology and Government of India, 2022; Indian Institute of Technology Bombay, 2023).

These centres are actively working towards developing novel, scalable, and affordable pathways for capturing CO_2 from various emission sources and converting it into chemicals or for permanent storage. In 2023, the Bombay National Centre of Excellence developed an energy-efficient CO_2 capture technology that converts CO_2 to carbon monoxide under electrocatalytic conditions at ambient temperatures in the presence of water, with potential applications in the steel sector (Ministry of Science and Technology, 2023). Additionally, new research has led to the development of an aqueous-based CO_2 capture technology capable of capturing CO_2 in industrial wastewater (Department of Science and Technology, 2024c).

The Bengaluru centre will serve as a nodal point for state-of-the-art research and application-oriented initiatives in the field of CCU. A recent development from the centre includes the establishment of India's first carbon dioxide-to-methanol facility in Telangana (National Centre for Carbon Capture and Utilisation (NCCCU), 2024).

3.3 Legal and Regulatory elements

Regulations governing the Indian cement industry encompass quality, safety, and environmental compliance. The Bureau of Indian Standards (BIS) takes a pivotal role in establishing cement standards. The Ministry of Environment, Forests and Climate Change is central to environmental regulation and policy formulation, covering different spheres of the environment, including emissions of air pollutants, consumption of water, utilisation of hazardous waste, noise generation, utilisation of forest land and wildlife areas. Operating on a national scale, the Central Pollution Control Board sets standards and facilitates coordinated environmental initiatives. At the state level, the State Pollution Control Boards issue clearances and monitor compliance, collectively ensuring a comprehensive approach to governing the industry.

For further details regarding the extensive regulations governing the Indian cement industry, please consult the appendix. However, we highlight two pivotal regulations that bear significance in the potential deployment of CCUS within the cement sector.

The first pertains to oil and gas legislation, wherein amendments could potentially enable the drilling of wells for CO_2 storage purposes. The second regulation concerns the Water Pollution Act, which oversees the protection of water resources from contamination. Potential amendments to this act may address regulations surrounding the long-term storage of CO_2 in subsurface formations.

These amendments can be accomplished in different ways. However, it must be noted that while each of these topics are critical for CO_2 injection the suggestions to amend will not diminish the regulatory or legislative governance structure that is currently in place for oil and gas operations.

Injection of CO_2 would have to be included with separate considerations, since there are additional requirements, especially for the subsurface. However, these additional requirements are within the capabilities of existing technologies used for oil and gas development.

- The purpose is to characterise the suitability of the geological, geomechanical, geophysical, reservoir, and other subsurface properties for CO_2 injection and storage.
- The design considerations for the wells – casing and tubing in particular – may also have additional requirements.

For example, subsurface storage characterisation for CO_2 follows techniques and methods that are similar to subsurface reservoir characterisation for oil and gas production. Similarly, subsurface surveying or evaluation methodologies for characterising CO_2 storage suitability are similar to surveying or evaluation methodologies that are used to identify the suitability of a potential reservoir. Regarding abandonment, all wells including legacy wells in a pre-defined near vicinity need to be assessed. However, not all legacy wells may need abandonment. Those that do can be abandoned according to the abandonment protocols in alignment with current laws since abandonment protocols are designed to impede all types of fluid movement. They can be compared/assessed in relation to best practices in jurisdictions with specific references to CO_2.

In-situ carbon mineralisation technology in basalts and peridotites is relatively new compared to CO_2 storage in sedimentary formations. There are fewer operational examples of this technology, partly because oil and gas operations have not traditionally focused on these types of rock formations. Identifying suitable storage sites that offer safe, rapid, and large-scale CO_2 mineralisation requires detailed subsurface analysis.

The complexities associated with in-situ mineralisation in mafic and ultramafic formations, compared to CO_2 storage in sedimentary formations, include the presence of fracture networks in fractured basalts and peridotites that could influence containment. There are various views from experts on the necessity of a top seal and the limitations of monitoring, measurement, and verification (MMV) methods, which typically provide 1D insights from a few monitoring wells rather than comprehensive 3D and 4D seismic data. Additionally, factors such as injection depth criteria, injection strategy, and the differences in injected fluids (CO_2 versus carbonated water) may necessitate different well designs.

Due to these factors, in-situ mineralisation technology in mafic and ultramafic rocks may require a distinct reservoir characterisation workflow compared to CO_2 storage in sedimentary formations. This distinct approach is essential to ensure operational safety, contain CO_2 and non-potable water within the injection zone, and safeguard both drinkable and potentially agricultural water sources, as required by jurisdictional regulations.

3.3.1 The Oilfields (Regulation and Development) Act, 1948

The Oilfields Regulation and Development Act passed in 1948 is a law passed by India's central government that authorises the central government to execute the following powers (The Oilfields (Regulation and Development) Act, 1948, 1948):

- Invalidate leases unless in accordance with this law.
- To make rules for mining leases and for mineral development.
- To modify rules that apply to existing leases.
- To inspect any site or location.

In this law, mining leases and mineral development are terms that are used interchangeably with oilfields, and oilwells. Additionally, mineral oils include natural gas and petroleum. This law can be applicable to the storage phase of CCS development. Wells drilled for the purpose of storing CO_2 in subsurface formations could fall under this law's jurisdiction since the law allocates the power to make rules that would regulate the "drilling, re-drilling, deepening, shutting down, plugging and abandoning of oil wells in an oilfield and for the limitation or prohibition of such operations and for the taking of remedial measures to prevent waste of or damage to oil". The law also allocates the power to make rules to regulate "the methods of producing oil in any oilfield, and the limitation or prohibition of such methods". Some methods of producing oil can require the injection of fluids into the wellbore, such as in enhanced oil recovery.

3.3.2 Water (Prevention and Control of Pollution) Act, (1974)

The Prevention and Control of Pollution of Water Act passed in 1974 is a law passed by India's central government authorising the central and state governments with several powers (The Water (Prevention and Control of Pollution) Act, 1974). Most relevant amongst these powers to CCUS, particularly the storage of CO_2 in subsurface formations, are the following:

- To take samples of effluents and reporting of analysis.
- Powers of entry and inspection.
- Prohibiting the use of wells for disposal of polluting matter.
- Emergency measures for polluted wells.
- Court action for pollution of water in wells.

A Central Board is entrusted with the power to promote the "cleanliness of streams and wells", to set water quality standards that are informed by taking samples and by performing the necessary analysis. Amongst the definitions that the law includes for stream are "sub-terranean waters", or commonly known as an underground source of water. The law makes specific mention of abatement of pollution of streams and wells as a function of the Board and prescribes that standards must be set for the treatment of effluents and waste discharge into streams and wells. The Board is also authorised to advise state governments appropriately. Emergency measures to remedy or mitigate pollutions into streams and wells is also entrusted with the Board, whether the offending parties are individuals or companies.

This regulation provides a potential pathway for carbon capture and storage specific regulations, focusing on the safe long-term storage of CO_2 to prevent the risk of leakage and avoid contaminating underground water sources. This strategy mirrors the measures implemented by the United States through the Safe Drinking Water Act.

Whilst this presents a possible route for the government to regulate carbon capture and storage activities, the government faces choices regarding legislation. One option involves enacting standalone carbon capture and storage specific legislation, which would comprehensively address all phases of carbon capture and storage projects throughout their lifecycle. Alternatively, the government could opt for project-specific legislation, tailored to regulate individual projects.

Specific carbon capture and storage legislation offers the advantage of consolidating all regulatory aspects into a single framework, enhancing clarity for investors and stakeholders. However, the process of developing new legislation may entail significant time and resources compared to amending existing laws.

3.4 Summary

The table below presents a summary of the current CCUS landscape in India. The current environment in India shows promise, with the NITI Aayog report outlining a policy framework and funding mechanisms to advance CCUS deployment. While India has set a net-zero target, CCUS is not explicitly included in the strategy. The new carbon credit trading scheme offers financial incentives for CCUS projects, supported by research from institutions like Indian Oil Corporation and national centres of excellence. However, a solid legal and regulatory foundation, whether through amendments to existing laws or the development of stand-alone CCUS-specific legislation, is needed to effectively regulate CCUS activities.

Table 2: Summary of policy, legal and regulatory issues in India

CATEGORY	SUMMARY
Strategy	The Niti Aayog report emphasises a hubs and clusters model for scaling up CCUS, focusing on key industries like steel, cement, and chemicals, with India's theoretical CO_2 storage capacity estimated between 400-600 gigatonnes. Funding is proposed through the Carbon Capture Finance Corporation, leveraging low-cost international funds and bonds, with potential reintroduction of a clean energy cess on coal. India's updated NDC targets include a 45% emissions intensity reduction and 50% non-fossil fuel capacity by 2030, aiming for net zero emissions by 2070. However, CCUS is not currently included in India's NDC, and a related private member's bill has seen limited progress in the legislature.
Policy incentives	The 2022 amendment to the Energy Conservation Bill introduced a domestic carbon credit trading scheme, establishing emissions intensity targets and a market for CCCs. The BEE and the Ministry of Power, in conjunction with other agencies, are developing the Indian Carbon Market, set to succeed the existing PAT scheme by 2024. India also contributes significantly to the global voluntary carbon markets, being the second-largest supplier of carbon offsets. Key institutions like the Indian Oil Corporation and the DST are involved in advancing CCUS technologies, with the DST launching initiatives like the International Carbon Capture Conference (IC3) and collaborating on projects with the Clean Energy Transition Partnership. Additionally, India has established National Centres of Excellence in Carbon Capture and Utilisation that focus on innovative CCUS technologies and applications.
Legal and Regulatory issues	India's cement industry is governed by a framework ensuring quality, safety, and environmental compliance, overseen by bodies like BIS and the Ministry of Environment, Forests, and Climate Change. For CCUS, potential amendments to the Oilfields Act could regulate CO_2 storage activities, while updates to the Water Pollution Act may address CO_2-related water contamination risks. The regulatory approach may include new CCUS-specific legislation or amendments to existing laws.

4.0 POLICY, LEGAL AND REGULATORY ISSUES RELEVANT FOR CCUS

This section provides a comprehensive review of the current best practices for CCUS strategies, policy incentives, and regulatory frameworks. It includes a detailed analysis of policy and incentives developed in various jurisdictions, such as the European Union (EU), the United Kingdom (UK), the United States (US), and Canada. By comparing these best practices with the existing CCUS landscape in India, we can identify gaps that may be hindering the progress of CCUS deployment in the country. The results of this gap analysis are presented in Section 5.

4.1 Strategy for CCUS

CCUS requires substantial investment, making it essential for the government to develop strategies to attract investments in CCUS projects. Around the world, governments have set ambitious decarbonisation targets that will necessitate significant CCUS capacity to achieve. Some salient examples of recent government activity on strategic level are included below.

4.1.1 EU Net Zero Industry Act

In March 2023, the European Commission (EC) introduced the Net Zero Industry Act. It has been officially published in the Official Journal of the EU since June 2024. The legislation establishes a framework of measures to strengthen Europe's net-zero technology products manufacturing ecosystem. The overall goal is to put Europe on a path to domestically manufacture at least 40% of its clean energy technology needs by 2030.

The Act identifies CCUS as one of the eight strategic net-zero technologies for which scaling up manufacturing capacity is critical to reaching the EU's climate goals. Specifically, for CCUS the Act proposes:

- Accelerating permitting and defining strategic net-zero projects: Requires the establishment of a "one stop shop" in each country to coordinate permitting of manufacturing projects, and sets detailed timelines for permitting procedures, with "strategic" projects given priority status.

- Increasing CO_2 injection capacity: Sets an EU-wide goal to achieve an annual CO_2 injection capacity of 50 million tonnes (Mt) by 2030. Notably, oil and gas producers will be asked to contribute to the 50 Mt target, calculated pro-rata based on each entity's share in the EU's crude oil and natural gas production (European Commission, 2023b).

4.1.2 EU Industrial Carbon Management Strategy

In order to achieve the recommended 90% net emissions reduction by 2040 and ultimately attain climate neutrality by 2050, the EU has modelled the requirements for capturing CO_2 over the coming decades. According to the modelling, the EU needs to capture and store at least 50 Mtpa of CO_2 by 2030, approximately 280 Mt by 2040, and around 450 Mt by 2050.

To facilitate the effective deployment of CO_2 transport infrastructure, several key measures are proposed. These include the development of a regulatory framework, market design, and infrastructure planning mechanism. Additionally, there is a focus on establishing emissions accounting rules within the EU ETS to

EFFORTS WILL BE MADE TO ENCOURAGE UPTAKE OF SUSTAINABLE CARBON AS A RESOURCE IN INDUSTRIAL SECTORS. THIS INCLUDES THE ESTABLISHMENT OF RULES FOR ACCOUNTING FOR ALL INDUSTRIAL CARBON MANAGEMENT ACTIVITIES.

EUROPEAN COMMISSION, 2024D

facilitate the transport of CO_2. The plan also advocates for minimum standards for CO_2 streams applicable to all industrial carbon management solutions. Efforts will be made to assess the potential for repurposing existing infrastructure for CO_2 transport and storage, and European coordinators could be nominated to support early infrastructure development.

Boosting carbon capture and storage involves the creation of a dedicated voluntary demand assessment and demand aggregation platform. This platform aims to connect CO_2 transport and storage providers with emitters. An Investment Atlas of potential CO_2 storage sites will be developed, along with step-by-step guidance for permitting processes for CCUS net zero strategic projects. Sectoral roadmaps will be formulated using a knowledge-sharing platform for industrial CCUS projects.

In the domain of carbon utilisation, efforts will be made to encourage a higher uptake of sustainable carbon as a resource in various industrial sectors. This includes the establishment of rules for accounting for all industrial carbon management activities (European Commission, 2024d).

4.1.3 UK Industrial Decarbonisation Strategy and CCUS vision

The Ten Point Plan led to the development of the UK Industrial Decarbonisation Strategy, which was launched in March 2021. The strategy sets out a pathway for the decarbonisation of the full range of the UK's industry sectors, which account for 1/6th of the UK's emissions and include metals and minerals, chemicals, food and drink, paper and pulp, ceramics, glass, oil refineries and less energy-intensive manufacturing. The strategy aims to reduce emissions from industry by at least two-thirds by 2035 and at least 90% by 2050 (HM Government, 2021a). It proposes to accelerate innovation of low-carbon technologies and aims to support first-of-a-kind CCUS demonstration projects from a range of industrial sources. Other measures proposed under the theme of supporting innovation include innovation in fuel switching, the development of industrial digital technologies, research into advanced technologies and research into product innovation.

The new strategy has allocated £210 million under the Industrial Decarbonisation Challenge to advance the decarbonisation of industrial cluster sites (UKRI, no date). The funding aims to support engineering and design studies for the rollout of decarbonisation infrastructure such as CCUS and hydrogen at these sites. Other funding initiatives to support various demonstration projects include the Energy Innovation Program (£505 million), the Net Zero Innovation Program (£1 billion), the Industrial Energy Transformation Fund (£315 million) and the Transforming Foundation Industries program (£66 million) (HM Government, 2021a). The Energy Innovation Program that was established in 2016 has advanced technologies such as CCUS and low-carbon hydrogen production. The Net Zero Innovation Fund is also expected to support innovation for CCUS.

The UK government has recently published the CCUS vision that sets out a plan to create a competitive CCUS market by 2035, including measures to:

- Move to a competitive allocation process for carbon capture projects from 2027 to speed up the building of the UK's CCUS sector.
- Create the conditions for projects that cannot transport CO_2 by pipeline to enter the market from 2025 onwards, using other forms of transport such as ship, road and rail.
- Establish a working group led by industry to identify and adopt solutions to reduce the cost of capturing CO_2.

As part of this vision announcement, the UK government has also provided updates on the progress of the developing clusters, including an expansion of the Track 1 cluster and an expedited timeline for the Track 2 cluster anchor projects by 2028-29 (Department for Energy Security and Net Zero, 2023).

4.1.4 Canada Carbon Management Strategy

In September 2023, Canada issued its Carbon Management Strategy. Canada aims to reduce greenhouse gas emissions (GHG) by 40-45% below 2005 levels by 2030 and has enshrined a commitment to reach net-zero emissions by 2050 into law. The Carbon Management Strategy outlines a vision under which carbon management technologies are deployed to help achieve Canada's climate objectives, underpinned by the development of a world class, multi-billion-dollar carbon management sector in Canada that supports inclusive, high-value employment and a more sustainable economy.

The Strategy estimates that Canada's capture capacity could grow from 4.4 Mt of CO_2 mitigation per year to 16.3 Mt of CO_2 per year by 2030[1], with significant further scaling required to help reach net zero by 2050. The strategy identifies five pathways where carbon management is expected to play a critical role to help achieve Canada's 2030 climate targets and enable a prosperous net-zero economy by 2050:

1. Decarbonising heavy industry, including oil and gas, cement, iron and steel and chemicals.
2. Low-carbon hydrogen production from Canada's abundant and low-cost natural gas.
3. Low-carbon dispatchable power, including from gas-fired power generation paired with CCUS, or BECCS, supporting Canada's goal of a net-zero electricity system by 2035.
4. CO_2-based industries, to manufacture fuels, chemicals, and building materials, or used directly, such as in food and beverage products, and in industrial processes.
5. Carbon removal through carbon dioxide removal (CDR) technologies, such as DACCS, BiCRS, and carbon mineralisation.

The strategy outlines actions in five priority areas:

1. Accelerating innovation and RD&D
2. Advancing policies and regulations
3. Attracting investment and trade opportunities
4. Scaling up projects and infrastructure
5. Building partnerships and growing inclusive workforces (Government of Canada, 2023).

[1] Canada's capture capacity in 2030 represents a point-in-time estimate based on existing policy commitments and assumptions regarding the timing of investment decisions, approvals and construction.

4.2 Laws and regulations to ensure safety and integrity of CCUS

CCS involves capturing CO_2 emissions from various sources, transporting it, and storing it underground in geological formations to prevent it from entering the atmosphere. Storage in geological formations is well understood and legal and regulatory frameworks for CCS have been developed in a number of global jurisdictions.

CCU is a broad term that covers processes that involve capturing CO_2 from flue gas or directly from the air and utilising it for various purposes, including converting it into a wide range of products such as renewable fuels, chemicals, and building materials. Such technologies are at various stages of development, and some are already commercially available today. Research into viable utilisation technology for captured carbon is ongoing, though at this time there is an anticipated imbalance between the volume of captured CO_2 and the end-source applications for it.

Utilisation may present significant economic value for project developers, but the benefits of utilisation from a climate mitigation perspective must be demonstrated to ensure that utilisation of CO_2 results in long-term removal of CO_2 from the atmosphere and/or other benefits including substitution of fossil-based products or energy sources. A comprehensive life-cycle analysis must be undertaken to determine if CO_2-based products can be produced with lower climate impact than conventional ones.

In addition to examining the duration and/or capacity of storage in a product, a life-cycle analysis must also look at the two main inputs for most processes – energy and water – in order to understand the full environmental impacts and benefits of any utilisation application.

Legislation for CCU is at an early stage of development and under intense debate.

The combined term, CCUS, as used in this report, refers to a combination of CCU and carbon capture and storage or either of these methods.

4.2.1 Defining the regulatory scope

To define the scope of CCUS regulations, a key consideration is how CO_2 will be classified in the legal and regulatory frameworks.

The legal classification of CO_2 has implications for the way existing regulatory frameworks might apply to CCUS operations. This is because classifying CO_2 as reflecting certain properties or classifying capturing, transporting, and storing CO_2 as similar to existing activities such as waste management may mean that aspects of existing regulations will apply to CCUS operations. Within international law, the London Protocol prohibits the export of waste to other countries for dumping at sea. CO_2 streams, for the purposes of geological storage, were initially included in this prohibition. However, in 2009, an amendment was made to the Protocol to allow for the export of CO_2 for geological storage under certain circumstances. Whilst the 2009 amendment to Article 6 is not yet in force it can be provisionally applied under certain conditions, resulting from an agreement between the Parties in 2019.

In addition, clear delineation of CO_2 ownership is crucial as it traverses the CCUS value chain, particularly in non-integrated projects where different entities may handle capture, transportation, and storage. While commercial contracts typically govern CO_2 ownership, existing regulations can also influence ownership obligations, especially in CO_2 transport. In jurisdictions with established oil and natural gas industries, pipeline regulations can be extended or modified to address CO_2 transport. For instance, in the United States, CO_2 pipelines often function as private carriers, retaining ownership of the CO_2 until it is delivered to a third party. The framework's regulatory scope can also influence CO_2 ownership transfer as it relates to the long-term management of a storage site. In certain cases, like in Norway, there is no specific mention of CO_2 ownership, and it is generally understood that the ownership of CO_2 transfers from the operator to the government along with the transfer of long-term stewardship. In other regions, such as Nebraska in the United States, regulations explicitly address the title of the stored CO_2 when transferring long-term site responsibility to the government (IEA, 2022).

Ownership and stewardship of CO_2 are closely connected. For instance, CO_2 offtake agreements between a capture facility and a T&S operator often free the capture facility from any liability for costs or damages resulting from CO_2 leakage during transport and storage. Additionally, in certain cases, after a specified period, the ownership, stewardship, and risks associated with CO_2 storage are transferred from the storage operator to a competent authority.

4.2.2 Permitting of carbon capture and storage operations

A streamlined and transparent permitting process is crucial for the success of CCUS projects. Governments must ensure that regulatory authorities have the necessary resources and capacity to assess, and process permit applications promptly.

4.2.2.1 Capture

Capture facilities are generally required to undergo environmental impact assessments. As part of their industrial emission permits, operators are mandated to implement the best available techniques for CO_2 capture, take appropriate measures to prevent pollution, and engage in public consultation. Additionally, in some regulatory frameworks like the EU's, facilities must meet certain carbon capture readiness requirements, which include ensuring the availability of suitable CO_2 storage sites and assessing the technical and economic feasibility of retrofitting installations for CO_2 capture.

4.2.2.2 Transport

When it comes to permitting CO_2 pipelines, it often involves modifying existing laws or utilising existing regulatory pathways rather than introducing entirely new measures. Although CO_2 transport entails different design specifications compared to natural gas, it shares many similarities with high-pressure gas transportation. Therefore, existing legal and regulatory frameworks for the oil and gas industries can be adapted to support the development of CO_2 pipelines. Although regulatory principles for CO_2 transport are not fully established, existing guidelines primarily emphasise providing third-party access, ensuring non-discrimination, and maintaining transparency.

Pipeline development may also require an environmental impact assessment.

4.2.2.3 Storage

The permitting process for CO_2 storage typically involves two main phases:

- Authorisation for site exploration licence/permit, which can be granted through various mechanisms, ranging from single licences to multiple authorisations. Given the similarities between exploration techniques for oil and gas and CO_2 storage, frameworks from the oil and gas industry can serve as a foundation for issuing licences/permits for CO_2 storage resource exploration. Key aspects of exploration authorisation should address rights clarification, information exclusivity, development exclusivity, time limitations, and storage market operation.

- Authorisation for injection and storage permit. Obtaining a permit will require detailed plans for project operation, inluding modeling results, monitoring plans, and specifics on project closure, such as decommissioning and rehabilitation plans. The injection permit will specify closure arrangements, post closure monitoring activities and transfer of liability (where applicable).

In the European Union, according to the CCS Directive, storage permit applications must include several key details. These include the total amount of CO_2 intended for injection and storage, the potential sources and transportation methods, the composition of CO_2 streams, injection rates and pressures, as well as proposed monitoring and post-closure plans, among other requirements (European Parliament and European Council, 2009). Member states are responsible for issuing exploration licenses and calls for interest for acreage, as well as managing the issuance of permits. Under the CCS directive, they have the flexibility to decide how to implement the directive at the national level, allowing for variations in regulations. (IEA, 2022)

In the US, the Environmental Protection Agency (EPA) regulates CO_2 storage permitting through the Underground Injection Control (UIC) program. Wells used for geological CO_2 storage are classified as Class VI under this program. EPA aims to review complete Class VI applications and issue permits when appropriate within approximately 24 months. This timeframe is dependent on several factors, including the complexity of the project and the quality and

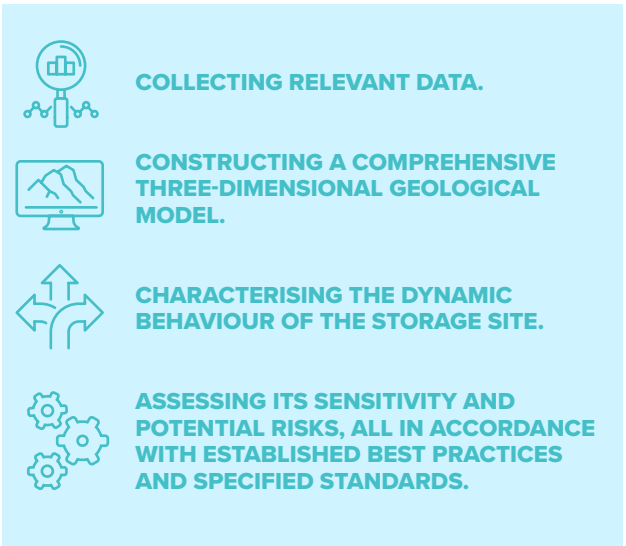
completeness of the submitted application. Although the EPA is the primary authority for the UIC program, states may obtain primary enforcement authority (often called primacy) to oversee the UIC program in that state, provided they meet specific requirements. Currently three US States have acquired primacy for Class VI wells: North Dakota, Wyoming and Louisiana.

4.2.3 Ensuring long-term safe and secure storage

4.2.3.1 Storage resource assessment

Assessing CO_2 storage resources involves evaluating the physical, chemical, and geological attributes of a potential site to determine its effectiveness in capturing and securely storing CO_2. It is crucial for legal and regulatory frameworks to establish guidelines for this assessment process to ensure the development of only suitable resources.

In the EU, the suitability of a storage location is determined by assessing both the site itself and its surrounding area against specific criteria. A formation can be designated as a storage site only if it poses no significant risks to the environment, public health, or CO_2 leakage. The EU follows a structured approach to this assessment, which includes:



In the US, operators of CO_2 storage sites must obtain a UIC Class VI permit from the competent authority to inject CO_2 for geological storage. The application process requires submitting extensive information before CO_2 injection, including:

- Maps and cross sections of the review area.
- Details on faults and fractures, ensuring they won't affect CO_2 containment.
- Data on the properties of the injection and confining zones, such as depth, thickness, mineralogy, and permeability.
- Information on geological stress, rock strength, and in situ fluid pressures.
- Seismic history of the area.
- Geological and topographical maps and cross sections.
- Locations of drinking water resources, wells, and springs relative to the injection zones.
- Baseline geochemical data of subsurface formations.

4.2.3.2 Ownership of pore space

Pore space refers to the voids between solid particles that make up the rock beneath the earth's surface. The ownership and regulation of this space, where CO_2 could be stored through sequestration, is a complex matter. Addressing this requires examining ownership rights concerning geological formations. Typically, rights to pore space encompass surface rights and the resources below, like coal, oil, and natural gas. This poses a significant challenge for companies seeking to utilise pore space for carbon capture and storage activities, as unclear categorisation of these rights can impede carbon capture and storage operations. Clarity on this issue can be achieved through the enactment of new legislation or the resolution of disputes through adjudication.

Provinces in Canada have authority over their subsurface resources, which includes pore space for CO_2 storage. Provinces are primarily responsible for regulating CCUS activities unless under federal jurisdiction (i.e., on federal lands, offshore, and lands crossing provincial or international boundaries). Regulations that ensure safe and permanent storage of CO_2 to the level required by the federal government have been established in Alberta, British Columbia, and Saskatchewan.

As the first Canadian province to address pore space ownership, Alberta's legislation (2010) designates the government of Alberta as the owner of all pore space, with the exception of pore space under federal land. Accordingly, a CO_2 storage project requires a grant of rights from the government whether by way of lease or tenure agreement covering the pore space.

In the European Union, deep subsurface pore space is typically owned by individual member states rather than private individuals. Consequently, for onshore storage projects undertaken in member states so far, pore space rights have been managed through specific contracts between national governments and storage operators. These contracts are established at the beginning of each project and cover both the injection and post-injection phases (UNFCCC, 2010).

4.2.3.3 Monitoring, Measurement and Verification plans

At the heart of ensuring safe and secure operations lies a robust Monitoring, Measurement, and Verification (MMV) plan or process. The primary objective of an MMV plan is to implement techniques and procedures aimed at detecting and mitigating CO_2 migration or leakage effectively. At a minimum the MMV should cover:

- Monitoring the injection facilities, storage site (including the CO_2 plume), and the surrounding environment, both before and during injection, to establish and maintain a baseline survey.
- Continuous comparison of ongoing monitoring results with the baseline survey data.
- Assessing the actual behavior of the storage site against its expected behavior as determined during the site characterisation process and monitoring results.
- Detecting, attributing, and assessing any significant leakage, unintended migration, or irregularities within the storage site.
- Quantifying, as mandated by the competent authority, the volumes of CO_2 associated with significant leakage or unintended migration.
- Identifying CO_2 migration.
- Detecting any significant adverse effects on the surrounding environment.
- Evaluating the effectiveness of any corrective measures implemented.

4.2.3.4 Financial security

In many of the CCS-specific regimes developed to date, the storage site operator is positioned as responsible for any damage that occurs during the exploration, operation, and closure phases of a storage site. As such, it is crucial to ensure that the operator is financially capable of addressing potential issues that may arise during site operations. In the EU, operators of a storage site are required to demonstrate that adequate provisions can be established to meet all obligations arising under their storage permit. The financial guarantee must be valid and effective when injection starts. It's important to note that financial security is one of the biggest challenges to carbon capture and storage. There is uncertainty around the appropriate level of security required, especially regarding whether it should include provisions for future purchases of carbon market allowances in case of carbon leakage.

In the US, Injection operators must provide financial assurance in the event of ceasing operations, and the amount of assurance is contingent on the projected cost associated with plugging and abandoning the injection well. The requirements for financial assurance also vary from state to state.

- In Louisiana the storage operator must pay a fee into a storage trust fund for a minimum of 10 years, capped at a maximum of US$5 million for each operator (Louisiana Government, no date) .
- In Kansas, the relevant authority collects injection fees, penalty fees for violations, permitting fees and well fees that feed into the state's fund. For example, the relevant authority can collect penalties for the release of CO_2 from storage facilities of up to US$10,000 per violation per day. The relevant authority can use the funds to pay for the cost of development and issuance of permits, compliance monitoring, inspections, well closures, underground storage closure, long-term monitoring and enforcement actions, among other activities (State of Kansas, 2023).
- In Wyoming, a special fund has been established to fund the measurement, monitoring and verification of storage sites following site closure certification. CO_2 storage permit holders pay into this fund either a lump sum closure fee or a fee per tonne of CO_2 injected (which has yet to be determined) (State of Wyoming, 2022).

4.2.3.5 Site closure

Regulations should establish clear guidelines outlining the necessary steps for closing a storage site and delineate the roles and responsibilities of all stakeholders in managing the site thereafter. The process of site closure begins once injection activities cease and typically involves decommissioning infrastructure, such as wells (except those required for ongoing monitoring) and rehabilitating the land. In instances where the responsible authority has made provision for assuming long-term stewardship of the closed site, the operator must demonstrate that proper decommissioning has been carried out and that there is minimal risk of future leakage. In the United States, the competent authority specifies procedures for well plugging, post-injection site care, and site closure for operators of Class VI wells under the Underground Injection Control (UIC) program.

4.2.3.6 Long-term storage liabilities and stewardship

To date, the issue of long-term liability has been one of the most challenging and complex issues associated with regulation of CO_2 storage activities. For many, the critical issue to be addressed remains who will bear the responsibility for the stored CO_2, following the cessation of injection and the site's formal closure.

To date, long-term liability for carbon storage sites has typically been addressed in one of three ways:

- Transfer to competent authority: Liability is transferred to the competent authority, but the operator must meet strict conditions to minimise future leakage risks before transfer.
- Operator responsibility: Long-term liability explicitly remains with the operator, who must continue monitoring and reporting to ensure safe storage, with reporting frequency varying.
- Operator retains responsibility indefinitely: Long-term liability is not explicitly addressed, implying that the operator retains responsibility for the storage site indefinitely.

The rationale for some jurisdictions transferring long-term stewardship to a competent authority post closure is that operators may be unwilling or unable to bear indefinite stewardship, which could discourage investment in storage development. Additionally, private operators may have limited lifespans compared to sovereign states, making indefinite stewardship impractical for them.

REGULATIONS SHOULD ESTABLISH CLEAR GUIDELINES OUTLINING THE NECESSARY STEPS FOR CLOSING A STORAGE SITE AND DELINEATE THE RESPONSIBILITIES OF ALL STAKEHOLDERS THEREAFTER...

CCS frameworks can require the operator to contribute to the costs associated with long-term stewardship of the CO_2 storage site. This can help reduce the financial exposure of the operator (or competent authority if responsibility is transferred) after site closure in the unlikely event of leakage.

According to the EU CCS Directive, liability is transferred to the state 20 years after the closure of a storage site, provided the operator demonstrates that the stored CO_2 will be securely contained. Upon approval of the transfer, the competent authority assumes responsibilities outlined in the Directive. However, it is important to note that the transfer does not provide operators with absolute immunity. Firstly, as outlined in the Directive, the transfer does not provide immunity against claims arising from civil and common law related to harm to human health, property, or economic loss. Secondly, the transfer does not extend to liabilities governed by member state statutory laws concerning environmental damage. The operator must make a contribution that covers the expected costs of monitoring the site for an additional 30 years.

In Australia under the federal Offshore Petroleum and Greenhouse Gas Storage Act, a closing certificate must be submitted when injection operations cease. The certificate holder is responsible for addressing any issues that arise within the first 15 years after site closure. If, after at least 15 years from the issuance of the site closing certificate, the Minister determines that there is no significant risk of major adverse impacts, the Minister may designate this period as a "closure assurance period." Following this designation, the Commonwealth government will indemnify the certificate holder against any ongoing liability for damages (Australian Government, 2023)

Alberta's Mines and Minerals Act, as amended by the Carbon Capture and Storage Statutes Amendment Act, 2010, allows the government of Alberta to assume long-term liability for storage sites. The Act makes it mandatory for storage site operators to contribute to the Post-Closure Stewardship Fund, which the provincial government will use for ongoing monitoring and any required maintenance and remediation.

4.2.4 Treatment of Carbon Removals

Achieving net-zero emissions inevitably entails the necessity of employing carbon dioxide removal (CDR) technologies. Regulatory challenges regarding CDR technologies primarily revolve around establishing rigorous accounting and certification mechanisms for CO_2 removals. Essential aspects include developing transparent methodologies for certifying removals, implementing adjustment frameworks to address potential CO_2 reversal or re-release, and preventing double counting of emissions, particularly in cases of overlapping frameworks.

Monitoring and reporting rules for carbon removals are currently being discussed by amongst other GHG Protocol and IPCC.

4.2.4.1 The European Carbon Removals Certification Framework

The European Parliament reached a provisional agreement on establishing a voluntary EU-wide certification scheme for carbon removals. This framework will provide assurance around the quality and governance of carbon removals and create a unified scheme that regulates the trading of carbon removal units. The definition of carbon removal reflects the approach taken by the UN IPCC. This includes permanent carbon removal including BECCS and DACCS, where CO_2 must be stored for several centuries through geological storage or where CO_2 is bound to a product for a period equivalent to geological storage.

The agreement tasks the EC to:

- Develop certification methodologies for different carbon removal activities.
- Establish an EU-wide registry to register activities as units (each unit is one ton of CO_2 removed). The registry will allow entities to sell/buy certified CDR units to achieve their carbon reduction activities.

The units can only be used for EU climate objectives and NDCs and do not contribute to the emission trading scheme obligations. However, that may be incorporated in the future (European Commission, 2024a). India has not yet taken steps to establish a framework for carbon removals.

4.2.5 Treatment of carbon capture and utilisation

CCU technologies are at various stages of development, and some are already commercially available today. Research into viable utilisation technology for captured carbon is ongoing, though at this time there is an anticipated imbalance between the volume of captured CO_2 and the end-source applications for it. Utilisation may present significant economic value for project developers, but the benefits of utilisation from a climate mitigation perspective must be demonstrated to ensure that utilisation of CO_2 results in long-term removal of CO_2 from the atmosphere and/or other benefits including substitution of fossil-based products or energy sources.

A comprehensive life-cycle analysis must be undertaken to determine if CO_2-based products can be produced with lower climate impact than conventional ones. In addition to examining the duration and/or capacity of storage in a product, a life-cycle analysis must also look at the two main inputs for most processes – energy and water – in order to understand the full environmental impacts and benefits of any utilisation application.

The regulatory framework for CCU for permanent storage is still in its early stages, but it differs from geological storage. Recently, the EU Commission drafted a regulation that exempts operators from the need to surrender emission allowances if the CO_2 is chemically bound into a product. This regulation outlines the criteria for a product to qualify as permanently bound, provides a list of CCU products that could be eligible, and describes the process for reviewing and updating this list based on new evidence and technological advancements (European Commission, 2024b). While this approach is still under review and subject to changes through consultations and approvals, it could potentially serve as a model for other jurisdictions looking to regulate CCU for storage.

4.3 Policies to incentivise CCUS and enable financing

4.3.1 Carbon Pricing

Implementing a price on carbon, whether through a cap-and-trade system or a carbon tax, stands as a powerful mechanism for accelerating decarbonisation across various sectors and technologies. This approach remains technology-neutral, fostering market-driven incentives to transition towards the most economically viable low-carbon alternatives. Effective implementation of carbon pricing relies heavily on ensuring compliance and maintaining market stability and environmental integrity. Moreover, the use of carbon pricing must not lead to distortions of competition between domestic producers and importer. “Border mechanisms” applying a carbon cost to importers are also being considered as a way to level the playing field and ensure global emissions continue to decrease.

Such mechanism can help mitigate the risk of carbon leakage and ensure a level playing field for businesses across borders.

Carbon pricing is an important mechanism to drive CCUS deployment. However, carbon prices are unlikely to be sufficient as a sole mechanism for the foreseeable future – this highlights the case for specific incentive policies to complement carbon pricing schemes.

4.3.1.1 EU Emissions Trading Scheme (EU ETS)

The EU ETS is the world’s first carbon market system. It is also the world’s largest carbon market with jurisdiction over all 27 EU member states and Norway, Iceland, and Liechtenstein (European Commission, 2022b). The EU requires mandatory participation for companies that operate in energy-intensive sectors including cement and especially those that generate GHG emissions as part of their operations.

The ETS cap-and-trade works by setting a cap on the total GHGs that can be emitted by all the entities under its jurisdiction. The cap is dynamically reduced over time to reduce annual emissions over time. Entities can trade allowances within the ETS that are allocated through auction sales or allocated for free. The free allocation of allowances is meant to address those sectors that are deemed to be at risk for carbon leakage. Some examples of high-risk sectors include refining, mining, cement manufacturing, and petrochemicals to name a few (EUR-Lex Access to European Union law and Official Journal of the European Union, 2019).

Free allocation of allowances is also used as a policy tool to incentivise the modernisation of the EU's energy sector through investments in clean technologies, diversifying energy sources, upgrading existing infrastructure, and modernising energy production and transmission (European Commission, 2021).

In 2021, the EU released its 'Fit for 55' legislative proposals which had modifications for the EU ETS (Global CCS Institute et al., 2021). The EU ETS transacts 40% of the EU's emissions and the new legislative proposals simplify the accounting and compliance rules while enhancing monitoring (European Union and European Council, 2022).

The EU's legal framework states that the EU Emissions Trading Scheme considers captured CO_2 that has been geologically stored (or safely stored) to be "not emitted". This means that EU ETS can in the future be a powerful incentive for CCUS, as capturing and storing emissions will enable industries to avoid paying for emissions allowances.

4.3.1.2 Carbon Border Adjustment Mechanism (CBAM)

In October 2023, the EU implemented a CBAM, imposing a carbon price on emissions generated during the production of carbon-intensive goods entering the EU. Upon full implementation, CBAM is expected to cover over 50% of emissions in the sectors included in the ETS. The CBAM is the EU's regulation to prevent carbon leakage (European Commission, 2023a). It has been in force since 1 October 2023, having been adopted by the EU Parliament in May 2023. The first reporting period is between 1 October 2023 and 31 January 2024. The EU has been steadily increasing its climate ambitions and goals. A consequence has been that while other international jurisdictions evaluate their own climate goals, the mismatch has resulted in carbon-intensive operations within the EU becoming comparatively expensive. This could lead to carbon leakage. Carbon leakage is defined as the subsequent arbitrage caused by the movement of carbon-intensive operations from the EU to countries whose climate goals are not on par with the EU, or increased imports from these countries.

The CBAM helps the EU level the playing field between local manufacturing and imports, by allocating a price to carbon-intensive goods imported into the EU. The price or tariff is aimed to also incentivise lower carbon operations outside of the EU. The CBAM will be gradually phased in. Initially, it will apply to carbon-intensive imports from industry producing aluminium, cement, electricity, fertilisers, hydrogen, iron, and steel.

Importers can report in one of three ways until the end of 2024. Starting 1 January 2025, only the full reporting method compliant with EU regulations will be accepted. The full reporting system will go into force a year later, on 1 January 2026, with the embedded GHG emissions of imported goods reported along with the associated quantity. Importers can buy CBAM certificates with pricing based on the weekly ETS allowance price. Certificates are surrendered based on the number of emissions embedded within the imports. If during production, a proven carbon price has already been paid, the amount paid can be reduced by the equivalent price.

The CBAM might encourage investments in CCUS outside the EU. Non-EU countries will need to adopt decarbonising technologies to avoid tariffs. If certain industrial sectors heavily rely on EU markets for exports, this could significantly drive investment in CCUS and similar technologies.

4.3.1.3 UK Emission Trading System

Launched in 2021 as a post-Brexit replacement for the EU ETS, the UK Emission Trading System sets a cap on the total GHG emissions allowable for certain industries. Industries, including cement, are mandated to purchase allowances for their emissions. This system, akin to the EU ETS, targets energy-intensive industries, providing a financial incentive for cement producers to embrace cleaner technologies like carbon capture and storage to mitigate emissions from their operations (Participating in the UK ETS, 2024).

4.3.1.4 Import Carbon Pricing Mechanism

Scheduled for implementation by 2027, the UK's Import Carbon Pricing Mechanism will extend carbon pricing to cover imports of cement from overseas. This ensures that these imports face a carbon price comparable to goods produced within the UK. Similar to the EU's carbon border adjustment mechanism, this initiative aims to encourage cement producers outside the UK to invest in emission reduction measures, including the adoption of CCS technologies. The mechanism creates a level playing field by aligning the carbon costs faced by domestic and imported cement, thereby incentivising global producers to adopt cleaner practices (Gov.UK, 2023).

4.3.1.5 Output-Based Pricing System

The Greenhouse Gas Pollution Pricing Act is the overarching framework for the federal carbon pollution pricing system in Canada. Under the Act, the Output-Based Pricing System (OBPS) is a regulatory emissions trading framework that operates on a performance-based model. Its purpose is to establish a pricing incentive for industrial emitters, encouraging the reduction of GHG emissions. The federal OBPS sets emission standards, known as output-based standards, for industrial activities on an emission per unit of output basis. Each covered facility calculates an annual emissions limit based on its level of production and the relevant output-based standard. Facilities that emit less than their annual limit earn surplus credits that they can remit, sell, transfer, or hold. Facilities with emissions above their annual limit must provide compensation for each tonne of GHG emissions above their limit. This approach is crafted to simultaneously safeguard competitiveness and prevent carbon leakage.

As of now, OBPS is applicable in Manitoba, Prince Edward Island, Yukon and Nunavut. The OBPS recognises storage in deep saline aquifers and depleted oil reservoirs, which provides an incentive to invest in CCUS technologies with permanent storage. Other provinces and territories have industrial, performance-based carbon pricing systems that currently continue to meet the federal benchmark stringency requirements – with provinces like Alberta providing CCUS incentives within their own carbon pricing system. If a province is not included in the OBPS, it is because it already has its own provincial pricing system in place. Although these pricing systems may have unique features, they generally follow a similar structure.

Canada's Greenhouse Gas Pollution Pricing Act was challenged in the courts but found constitutional by the Supreme Court of Canada in 2021 (Government of Canada, 2022). Canada's excess emissions charge was raised to CA$80 per tonne of CO_2 to in 2024 and will increase by CA$15 per calendar year to CA$170 per tonne by 2030.

4.3.2 Specific incentives

There are various incentives that the government can implement to drive demand for decarbonisation technologies and ultimately decrease the cost of abatement. These typically take the form of direct grant funding, tax credits, operating subsidies, and revenue stability schemes such as carbon contracts for difference (CCfDs). Certain incentives can be designed to support significant investments that the private sector might not otherwise pursue, for example CO_2 transport infrastructure.

4.3.2.1 Tax credits

4.3.2.1.1 Canada's CCUS Investment Tax Credit

Legislation implementing an investment tax credit (ITC) for CCUS projects received Royal Assent in Canada in June 2024 and is available for projects retroactively from 1 January 2022 until 31 December 2040. The CCUS ITC is designed to support CCUS projects that capture, transport and permanently store CO_2 in dedicated geological storage or permanently sequester CO_2 in concrete. For a project to be eligible, the CO_2 must be directly captured from the air or from point sources that would otherwise be released into the atmosphere and at least 10% of captured CO_2 must go towards an eligible use as defined in the Income Tax Act. The CCUS ITC is available for a broad range of CCUS applications across different industrial subsectors, including hydrogen and direct air capture projects.

The implementation and administration of the CCUS ITC is a collaborative effort involving multiple departments including the Canada Revenue Agency (CRA), Finance Canada, Environment and Climate Change Canada (ECCC), and Natural Resources Canada (NRCan).

The tax credit rates for qualified CCUS expenditures are:

Expenses between 2022 to 2030 are:

- 60% for Direct Air Capture (DAC) projects.
- 50% for capture equipment.
- 37.5% for utilisation, storage, and transportation.

Expenses between 2031 to 2040 are:

- 30% for DAC projects.
- 25% for capture equipment.
- 18.75% for utilisation, storage, and transportation.

Information on the Government of Canada's suite of investment tax credits, including CCUS, can be found at Clean economy investment tax credits (ITCs).

4.3.2.1.2 The US's 45Q tax credits

The US Federal Internal Revenue Code (Federal tax code section 45Q) provides a specific federal tax credit for CO_2 captured and either geologically sequestered, used in enhanced oil recovery or permanently trapped in chemical products and other commercial operations. (Global CCS Institute and Matt Bright, 2021; United States Congress and Congressional Research Service, 2021).

After the passage and enactment of the Inflation Reduction Act in August 2022, the carbon capture provisions that provide incentives for CCS projects were significantly enhanced (Clean Air Task Force, 2022; United States Department of Energy and Department of Energy Office of Policy, 2022). The new law broadens the ability to transfer the 45Q tax credit. During the twelve-year period, the entity that originally receives the 45Q tax credit can transfer the entire amount or any portion of it to another tax-paying entity in exchange for a cash payment. Furthermore, this cash payment will not be taxed.

Other details are summarised below and in Table 3.

a. The new law now provides entities an option to receive the 45Q tax credit as a direct payment. This is like the entity receiving a tax credit for overpaid taxes. The durations are different depending on the type of entity.

   i. Five years for for-profit entities after initiation of the project.

   ii. Twelve years for tax-exempt entities.

b. More types of facilities now qualify since the IRA reduced the annual CO_2 capture threshold to:

   i. 1,000 tonnes for DAC facilities.

   ii. 12,500 tonnes for industrial facilities.

   iii. 18,750 tonnes for power generation facilities (at least 75% of the CO_2 must be from a unit that generates electricity and has capture equipment installed).

c. Extends the deadline to begin construction by 1 January 2033.

d. Continue allowing tax credits to be claimed for 12 years from the time the equipment begins service.

Table 3: Increases to the 45Q tax credit from the Inflation Reduction Act of 2022

ACTIVITY		BEFORE IRA*	AFTER IRA*
Geological storage of CO_2	From power generation and industrial facilities	50	85
	From direct air capture (DAC) facilities	50	180
Utilisation of CO_2	From power generation and industrial facilities	35	60
	From DAC facilities	35	130

* US$/tonne of CO_2

It should be noted that to qualify for the full value of the tax credit, operators must meet specific labour and apprenticeship requirements.

4.3.2.2 Revenue stability schemes

4.3.2.2.1 UK Industrial Carbon Capture Model

The objective of this model is to incentivise existing industrial facilities to invest in carbon capture to decarbonise. This model will provide a contract of up to 15 years between emitter and counterparty that will pay emitters per tonne of captured CO_2 to cover the additional costs of deploying carbon capture and offer risk protections in specific circumstances (e.g. unplanned instances where the transport and storage network is unavailable) if obligations are met. Contracts will be funded from the exchequer via the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme (Department for Business, 2022).

4.3.2.2.2 The Netherlands - SDE++ mechanism

The existing Netherlands SDE mechanism for subsiding renewable energy generation was expanded to the SDE++ in 2020, making it applicable to multiple decarbonisation technologies, including electrolytic hydrogen and CCUS. The unprofitable component of investment is covered by an operating subsidy covering both the OPEX and CAPEX of the climate abatement technology. A series of bidding rounds are administered by the Netherlands Enterprise Agency on behalf of the Ministry of Economic Affairs and Climate Policy. There is a cap on the total volume of CCUS that can be supported, set at 9.7 Mtpa for industry and 3 Mtpa for power. The budget is determined annually; €5 billion in 2021, up to €11 billion in 2022, and €9 billion in 2023. Projects with the lowest subsidy requested per tonne of CO_2 abated win the subsidy. The CCUS subsidy grant lasts for a period of 15 years (Clean Air Task Force, 2024).

4.3.2.2.3 Germany - Climate Protection Contracts

The German Federal Ministry for Economic Affairs and Climate Protection (BMWK) announced a subsidy scheme for industry decarbonisation in March 2024 that includes a funding program called Climate Protection Contracts, also known as CCfDs. The scheme will offset the added cost involved compared with conventional procedures for a period of 15 years.

4.3.2.3 Grant funding

4.3.2.3.1 Bipartisan Infrastructure Law

The passing of the bipartisan Infrastructure, Investment, and Jobs Act (a US Federal legislation) in 2021 provided the US Department of Energy (DOE) over US$62 billion in funding for investments in new technologies, energy efficiency, power, and manufacturing (United States Department of Energy, 2021b). The law is also known as the Bipartisan Infrastructure Law.

The Act authorises US$21.5 billion of this funding to be used for research hubs and clean energy demonstrations. Almost half of this amount, more than US$10 billion is earmarked for industrial emissions reduction, carbon capture and DAC (United States Department of Energy, 2021b). The DOE refers to this area of infrastructure development as carbon management, renaming the Office of Fossil Energy as the Office of Fossil Energy and Carbon Management, or FECM (Office of Fossil Energy and Carbon Management and Department of Energy, 2021).

A breakdown of the funding available for CCUS related technological development is listed in Table 4 (Kelly Johnson et al., 2021; United States Department of Energy and Office of Fossil Energy and Carbon Management, 2021). The funding is disbursed through a combination of grants, loans, and cooperative agreements. In addition, the DOE's Office of Clean Energy Demonstrations (OCED) has also been allocated US$8 billion for hydrogen hub development. The DOE also plans to assist States with their efforts to accelerate the development of CCUS projects by making US$20 million in funding available to four projects (United States Department of Energy, 2021a).

Table 4: DOE Funding from the Infrastructure, Investment, and Jobs Act

PROGRAM	FUNDING, US$	FISCAL YEARS
Direct air capture (DAC)	3.5 billion	2022 – 2026
DAC Technology Prize Competition	115 million	2022
Carbon Capture Technology Program (CCUS FEED*)	100 million	2022 – 2026
Carbon Storage Validation and Testing (for large scale commercial carbon sequestration projects)	2.5 billion	2022 – 2026
Carbon Utilisation Program (for lowering GHG emissions through CO_2 utilisation)	310 million	2022 – 2026
Carbon Capture Demonstrations and large pilots through the OCED	3.5 billion	Not specified
CO_2 Transportation Infrastructure Finance and Innovation Program through the DOE's Loan Program Office and FECM	2.1 billion	Not specified

* Front-End Engineering and Design.

4.3.2.3.2 UK CCS Infrastructure Fund

The CCS Infrastructure Fund (CIF) is a £1 billion fund to support CCUS investments in the UK. The primary purposes of the CIF are twofold. The CIF is to serve as a source of funds to cover (1) the capital costs of CO_2 transport and storage (T&S) infrastructure, and (2) early industrial capture projects (Department for Business Energy and Industrial Strategy and HM Government, 2021b).

Through the proceeds from the CIF, the UK Government seeks to establish and develop a transport and storage (T&S) network that would support the development of CCUS clusters. The T&S network is the main CCUS infrastructure component that the fund seeks to support. Government intervention is justified due to difficulty in ascertaining future demand, the long timeframes, and significant project risks associated with building out a T&S network. With the right policy support from the UK Government, the public and private sectors share the project risk and future returns on investment. This infrastructure is crucial to supporting many types of CCUS projects, including at DAC facilities, low carbon hydrogen production facilities, and gas power plants to name a few.

4.3.2.3.3 EU Innovation Fund

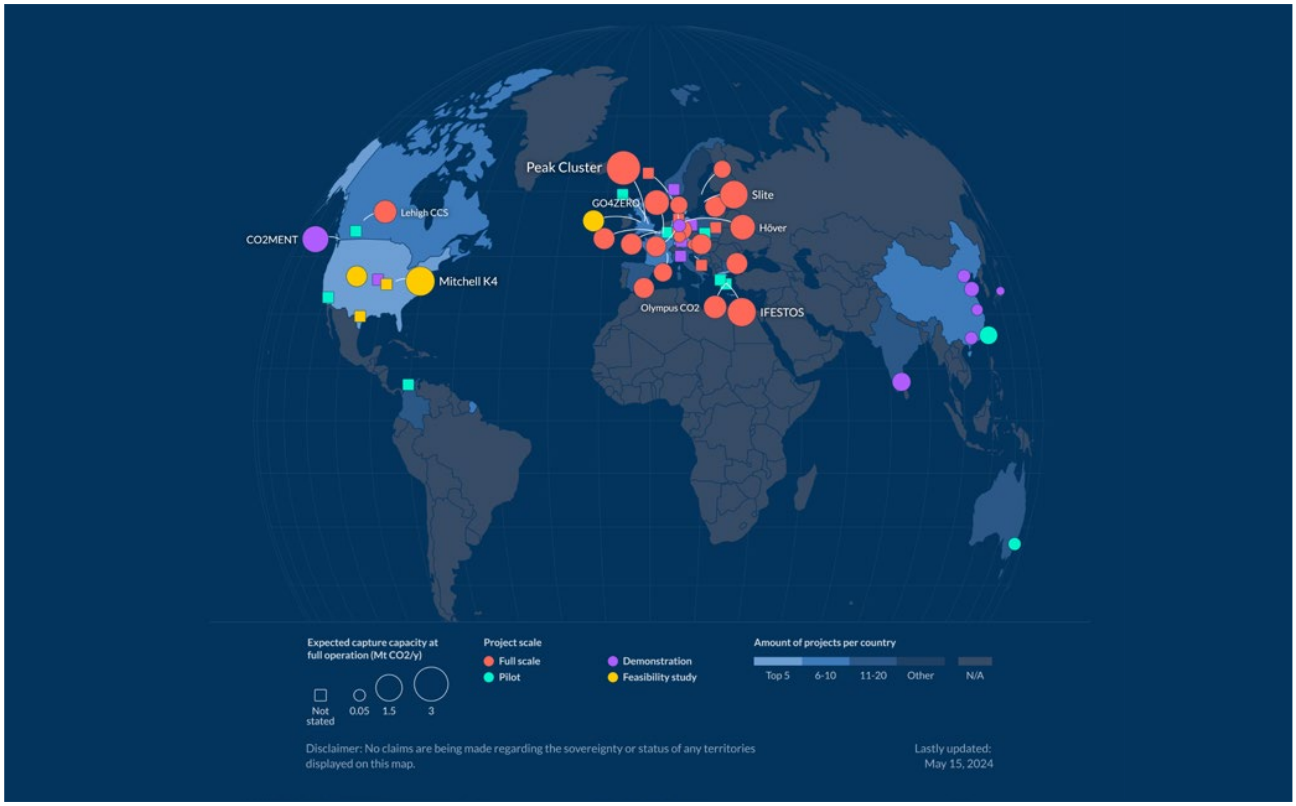
Fuelled by revenues from the EU ETS, the Innovation Fund is dedicated to promoting the implementation of cutting-edge clean technologies. The funding, potentially amounting to €40 billion between 2020 and 2030, varies based on carbon prices. Notably, each successive call for projects under the Innovation Fund has witnessed a growing number of applications featuring a CCUS component.

In November 2022, the European Commission initiated its third call for large-scale projects. A noteworthy development is the division of the Innovation Fund budget, which has doubled due to the rise in ETS prices, now standing at around €3 billion. A significant portion, specifically €1 billion, has been earmarked for the funding of CCUS projects under the category of 'general decarbonisation' (European Commission, 2022b).

Several CCUS cement initiatives have garnered support from the EU Innovation Fund, including:

- **Gezero Carbon Capture Project:** Heidelberg, Geseke plant, Germany. The project is dedicated to achieving full decarbonisation of cement production and is expected to result in an annual reduction of 700,000 tonnes of CO_2.
- **IFESTOS Project:** TITAN Cement, Kamari plant, Greece. This project focuses on capturing CO_2 emissions from cement production, with the primary objective of producing net-zero-emission cement, thereby contributing to sustainable practices within the cement industry.
- **KOdeCO Net Zero CCUS Project:** Holcim, Koromačno, Croatia. The project is centred around capturing and storing CO_2 emissions from the plant, aiming to advance carbon capture technologies and work towards achieving net-zero emissions in cement production.
- **GO4ZERO Project:** Holcim, Obourg plant, Wallonia, Belgium. The project aims to operate a carbon-negative clinker kiln by coupling an oxy-combustion process with a large-scale carbon capture initiative.
- **eM-Rhone Project:** Elyse, Rhone Valley, France. This project will combine renewable energy hydrogen production, carbon capture from an existing cement plant, and e-methanol synthesis (CCS Europe, no date).
- **K6 Project:** EQUIOM and Air Liquide, France. The project will deploy a first-of-its-kind industrial-scale combination of an airtight kiln and cryogenic carbon capture technology, resulting in the avoidance of 8.1 Mt of CO_2e.
- **ANRAV Project:** Devnya Cement, Bulgaria. The ANRAV project aims to establish Eastern Europe's first complete CCUS value chain by capturing CO_2 at the Devnya Cement Plant in Bulgaria and transporting it through onshore/offshore pipelines to be stored in a depleted gas field in the Black Sea.
- **Go4ECOPlanet Project:** Holcim, Kujawy Cement Plant, Poland. The carbon capture installation, which will be launched in 2027, will capture 100% of the CO_2 emissions caused by clinker production. In the span of 10 years, it will capture over 10 Mt of CO_2.
- **Carbon2Business Project:** Part of the Westküste 100 project, Holcim's Lägerdorf plant, Germany. The project involves capturing carbon to be used as synthetic fuel for the mobility sector and as feedstock for the chemical industry (European Commission, 2024c) .

Figure 1: Where have carbon capture projects been announced?



4.3.2.4 Off-take agreements

4.3.2.4.1 Canada Growth Fund

The Canada Growth Fund is a CA$15 billion independent and arms-length public investment entity that aims to help stimulate private capital infusion into Canada's clean economy. Detailed provisions for this Fund were outlined in the 2022 Fall Economic Statement. Legislation and legislative amendments introduced in 2023 operationalised the fund as announced in Canada's 2023 Budget.

The primary objective of the Canada Growth Fund is to expedite private capital investment in projects focused on decarbonisation and clean technology, including CCUS. This strategic investment aims to not only contribute to meeting Canada's climate targets but also to foster economic diversification. The funding is currently being used in the form of offtake agreements (Department of Finance Canada, 2022).

Among the financial instruments offered by the Canada Growth Fund to bolster clean growth projects are contracts for differences. These contracts serve as a risk mitigation mechanism by providing a safeguard for the future carbon price, thereby enhancing predictability. This proactive approach is designed to reduce the inherent risks associated with significant projects aimed at reducing Canada's emissions (Department of Finance Canada, 2022).

4.3.2.5 Taxonomy

4.3.2.5.1 EU Taxonomy

The EU Taxonomy, a classification system guiding investments towards sustainable projects. The taxonomy is a classification system that defines criteria for economic activities that are aligned with a net zero trajectory by 2050. It establishes carbon intensity thresholds for sectors like cement, steel, chemicals, hydrogen, and natural gas. This framework also creates a conducive environment for CCUS. CCUS becomes an appealing option for investors when project developers can showcase that integrating CCUS technology can reduce their carbon intensity to levels below the taxonomy's standards ('Carbon Capture and Storage the new driver of the EU Decarbonisation Plan', 2023).

4.3.3 Demand creation for low-carbon and near-zero materials

Demand for low-carbon and near-zero products and materials is a driver of decarbonisation of supply sectors through their adoption of technologies including CCUS technologies. Demand may be from the public and/or private sector and can stimulate a competitive market and result in a "green premium" for lower carbon products.

Public procurement: With 40-60% of global concrete consumption driven by the public sector, public procurement has scope to be particularly impactful for the cement industry. Similarly, with 20% of India's GDP allocated to public procurement, the government holds significant direct influence over the demand for low-emission cement.

Private Procurement: Governments also have a role in demand creation for low-carbon and near-zero products through policies that influence or directly dictate private procurement.

Procurement frameworks can be designed to be at product level and/or project level.

4.3.3.1 Measurement Standards for product embodied carbon data

Consistent and comparative carbon footprint data is essential for low carbon procurement. Global Warming Potential values from Environmental Product Declaration (EPD) are the typical data recognised in low carbon product schemes in markets where green public and private procurement are being used. EPDs are the adopted data source by global schemes promoted by First Movers Coalition (World Economic Forum), Concrete Zero (Climate Group) and the Clean Energy Ministerial's Industrial Deep Decarbonisation Initiative co-led by India and the UK.

EPDs have been established in standards notably ISO 21930:2017(International Organization for Standardization., 2017) and EN 15804(Circular Ecology, no date) which accords with ISO 21930 and provides the detailed rules to make the ISO standard applicable. EN15804 has been widely adopted across the globe with the exception of North America, which has very similar, but not identical rules for EPDs. EN15804 is the EPD standard used in India.

The Clean Energy Ministerial (CEM) Industrial Deep Decarbonisation Initiative (IDDI) published a whitepaper (International Deep Decarbonisation, 2023) in December 2023 titled: "Driving consistency in the Greenhouse Gas Accounting System: A pathway to harmonized standards for steel, cement, and concrete", and has a project on harmonisation of EPD standards which seeks to address the differences between EN15804 and the North American PCRs.

Current versions of Environmental Product Standards do not account for carbon captured during the production process. However, relevant standards setting committees in Europe (CEN/TC 350/WG 3) and the US (Cement Product Category Rules (PCR) revision committee), among others, are aware that there will be a need for this. In the former, whilst CCUS is not explicitly stated, the current rules would allow carbon that is captured safely and stored to be deducted from the embodied carbon value of a product, whilst any emissions associated with the capturing process would be allocated to the product.

In 2022, the Treasury Board of Canada Secretariat introduced the Standard on Embodied Carbon in Construction. This standard mandates the disclosure of the carbon footprint associated with structural materials and sets targets for reducing emissions below a specified baseline. Notably, the standard allows for CCUS technologies and specifies that, if they are employed to diminish the global warming potential (GWP) of concrete, such as through carbon mineralisation, a product-specific Environmental Product Declaration (EPD) is required to validate the associated reduction in GHG emissions. As per the standard, the total project GHG emissions from ready-mix concrete shall be at least 10% less than those calculated using the GWPs of the baseline mixes in the Regional Industry Average EPD (Standard on Embodied Carbon in Construction, 2022).

4.3.3.2 Reporting and verification for product embodied carbon data

Companies can report the embodied carbon data for products by publishing EPDs. These documents are, by definition, third party verified and publicly available through EPD "libraries" and some companies make them available on their websites. In the US, over 100,000 EPDs are available on the EC3 library. In other countries there is yet to be any reason for a supplier to publish an EPD, and there are no EPDs available.

Suppliers who are early to adopt EPDs, may choose to invest in the resources to publish an EPD, thereby reporting the embodied carbon of a product, so as to promote that product specifically and/or as part of marketing their broader sustainability credentials. EPD publication is seen to increase when demanded through private sector procurement: when it becomes a requirement to report embodied carbon via a GWP value, or, as a precursor to this, to provide an EPD irrespective of the values published. Demand for EPDs has now reached such demand in the West Coast of the US that there are approximately 100,000 EPDs on the library EC3, and the vast majority of these are concrete. Across the border in Canada, all cement plants have published EPDs for cement products.

In countries where EPDs are now common such as the US, Canada and many European countries, there is an infrastructure to deliver EPDs (for example "programme operators" that publish EPDS in libraries, EPD third party verifiers and software tools to help suppliers). Even in these countries the demand for EPDs is increasing and there is ongoing investment. For example, part of the US Inflation Reduction Act is funding to support the cement and concrete industry produce EPDs for their products. For countries where EPDs are in their infancy, the EPD infrastructure will need to be developed, but there is much to adopt and learn from elsewhere.

For example, the GCCA EPD tool, developed and used since 2014 and with the latest version released in December 2023, provides a cloud-based interface for members and non-members to produce cement and concrete EPD data to the latest standards. The software tool is pre-verified so that the cost of verification of each product EPD is minimised. The tool is applicable in all countries, including India where it is already being used (Standard on Embodied Carbon in Construction, 2022).

4.3.3.3 Definitions and targets for low-carbon and near-zero cement and concrete

Definitions

The IEA has proposed a global labelling system for low-carbon and near-zero cement in its report "Achieving Net Zero Heavy Industry Sectors in G7 Members (International Energy Agency, 2022). This system employs a sliding scale approach, where thresholds for cement to achieve specific emissions performance labels are determined by the clinker-to-cement ratio. Six categories, ranging from near-zero carbon to low carbon A, B, C, D, and E cements, are defined in terms of $kgCO_2e$ per tonne of cement. As an example, for a clinker cement ratio of 1.0, near zero emissions is $125kgCO_2e/t$.

THE GCCA EPD TOOL IS A PRE-VERIFIED, WEB-BASED CALCULATION TOOL DESIGNED TO STREAMLINE THE CREATION OF ENVIRONMENTAL PRODUCT DECLARATIONS (EPDS) FOR AGGREGATES, CLINKER, CEMENT, CONCRETE, AND PRECAST ELEMENTS.

FOR MORE DETAILS, VISIT THE GCCA WEBSITE

The IDDI is using the IEA cement methodology as a robust starting point for its own cement definitions.

The First Movers Coalition defines near zero cement as 184kgCO_2e/t, but during 2024 is reviewing this figure. The initiative administered by World Economic Forum is also reviewing its definition of near zero emission concrete, for which it categorises concrete into different strength bands.

The Climate Group have a “Concrete Zero” low carbon procurement initiative. This uses UK concrete EPD GWP data to develop a threshold value that is a percentage below an average EPD. The data, values and averages are for different categories of concrete strength.

The Concrete Sustainability Council (CSC) also has a scheme for low carbon concrete definitions that categorises concrete in strength bands. CSC uses percentage reductions below a benchmark value calculated for concrete’s made from Ordinary Portland cement, where percentage reduction bands are prescribed a “star” level. CSC leaves it to countries to set their benchmark value.

The GCCA has consulted publicly on a methodology and numerical values for concrete definitions that follows the IEA in terms of similar global bands A to E and “near zero” definitions that are defined by the global destination in 2050 of net zero. For concrete these definitions are a continuum from low strength to high strength concrete – analogous to the FMC, Climate Group and CSC approach of categorising by strength.

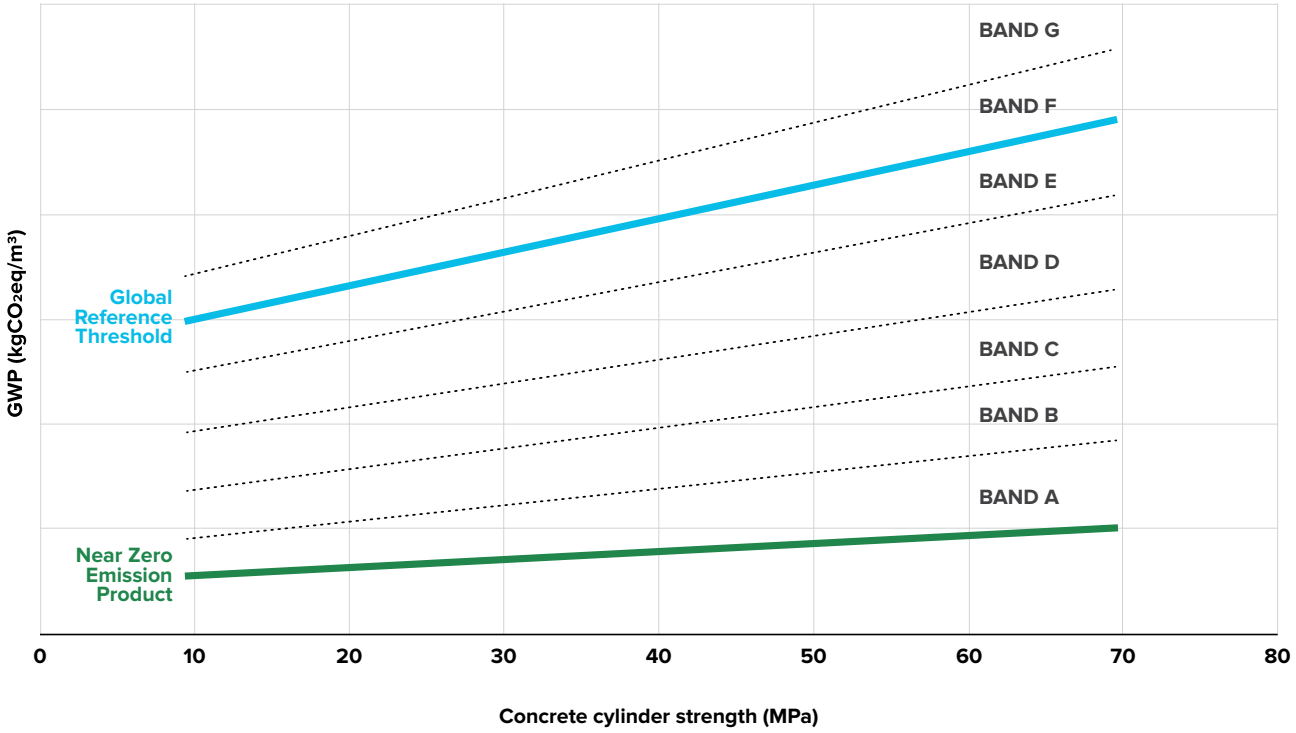
In detail, the proposed GCCA concrete methodology is as follows:

- To set a global reference threshold for concrete (top of band E), data was gathered from major cement-consuming countries including India, Vietnam, the USA, Turkey, Indonesia, Brazil, Japan, Mexico, Egypt, and Germany. The carbon footprint of each concrete product in every country was computed using the GCCA EPD tool. These initial country threshold graphs were then consolidated through a weighted averaging method to form a global threshold graph. The weighting factor employed is the total cement production of each respective country.

- The near-zero emissions threshold for concretes was defined using the IEA’s near-zero cement emissions data, adoption of a clinker-to-cement ratio of 0.52 as per the GCCA roadmap, a 14% reduction in binder content as per the GCCA roadmap and exclusion of emissions from other materials, transport, and manufacturing processes.

- Following the establishment of the global reference (top of band E) and near-zero emission thresholds, five incremental bands (A through E) were defined. Furthermore, two additional bands, F and G, are proposed to ensure no concrete products are excluded from the procurement process. These additional bands allow countries flexibility in inclusion, ensuring that all producers and products can participate in the decarbonisation effort.

Figure 2: Schematic representation of GCCA global concrete definitions (GCCA, 2024)



Targets

As noted above in definitions, the First Movers Coalition (FMC) initiative has targets that are inextricably linked to the definitions. The definition of near-zero cement or concrete is, for the FMC member that is procuring cement/concrete, the target together with the year 2030 and a percentage of product purchased in that year. The Climate Group to some degree also links targets with definitions.

The approaches of IEA, IDDI and GCCA are distinctive in that targets can be set by countries, states, cities or companies fully in response to their own opportunities and challenges to decarbonise. The targets are described using the definitions.

The approaches of IEA, IDDI and GCCA are also that the definitions are static with time. It is the targets that are lower GWP values over time, not the definitions.

The GCCA recommend that targets must be:

- Stretching and provide the long-term certainty needed to deliver the demand signal to enable the industry to decarbonise.
- Realistic to ensure customers can find suppliers.
- Congruent with GCCA global roadmap taking into account national opportunities/challenges, or national/local roadmaps where they exist. (International Energy Agency, 2022)

4.3.3.4 Low-carbon procurement at project level

In the previous three sections, standards, measurement, reporting, definitions and targets have been explained in terms of product level. All of these stages also apply at project level.

The IDDI is supporting member countries with low carbon product and project procurement. In recognition that low carbon procurement at product level is relatively speaking less complex, countries can commit to initiatives at product level only, and commitments at project level, if made, are for a later year than product level commitments.

The GCCA Concrete Future Roadmap to net zero concrete identified that design and construction efficiency will contribute to 22% of the decarbonisation of the sector in 2050. This is one indication why low carbon procurement at a project level is beneficial: all the potential levers to decarbonisation are incentivised.

One of many examples of project level procurement is CALGreen (US, California), which mandates compulsory reductions in embodied carbon for new construction and significant renovations of commercial buildings exceeding 100,000 square feet and school buildings surpassing 50,000 square feet. This promotes the adoption of low-carbon construction materials and techniques. If the reduction targets are set appropriately, it has potential for supporting CCS in cement production. (CALGreen Mandatory Measures for Embodied Carbon Reduction, 2023).

4.3.4 Renewable Energy Support

To optimise emission reduction through CCUS, affordable access to renewable energy is crucial. Integrating CCUS with cement plants could double energy demands; sourcing this energy from fossil fuels might hinder emissions reduction. India leads in renewable energy, with 130 GW of new capacity, quadrupling since 2015. However, coal still dominates, constituting 70% of power generation, projected to remain at 50% by 2030, with 27 GW of new coal plants in progress. Fossil fuel subsidies in 2021 were nine times higher than those for renewables, but reduced to four times in 2022. (Climate Action Tracker, 2024b). India's progress in renewables must accelerate alongside transitioning from coal to ensure industrial emission reduction.

4.3.4.1 Renewable Energy Directive (RED III)

The Renewable Energy Directive, amended in October 2023 (RED III), aims to increase the share of renewable energy sources in final energy consumption. The EU Council legislated a target of a 42.5% renewable energy share by 2030. Biomass is considered a renewable energy resource if its use adheres to sustainability criteria, emphasising sourcing and biomass type (European Commission, no date).

Apart from the set target, a robust policy framework will support the electrification of various sectors, with enhanced sector-specific renewable targets for heating and cooling, transport, industry, buildings, and district heating. The directive's primary aim is to solidify the EU's position as a global leader in renewable energy. It seeks to make renewable energy widely accessible at a low cost, promoting homegrown sources and reducing Europe's reliance on external suppliers.

4.3.4.2 Clean Electricity Regulations

In 2023, Canada introduced the draft Clean Electricity Regulations (CER), intended to be enacted under the Canadian Environmental Protection Act, 1999, by 1 January 2025. The CER sets performance standards for emitting electricity generating units to support net-zero electricity by 2035 target, which could encourage the adoption of CCUS technologies.

INDIA'S PROGRESS IN RENEWABLES MUST ACCELERATE ALONGSIDE TRANSITIONING FROM COAL TO ENSURE INDUSTRIAL EMISSION REDUCTION.

Units must not exceed 30 tonnes of CO_2 per GWh, effective from 1 January 2035, with certain existing units given extended timelines. Approximately 98% of emission reductions from 2024 to 2050 are anticipated in Alberta, Saskatchewan, Ontario, Nova Scotia, and New Brunswick, necessitating significant investments in non-emitting electricity sources. Other provinces are not expected to require substantial non-emitting generation buildout based on the CER (Government of Canada, n.d.).

4.3.5 Infrastructure development

4.3.5.1 Regional Clusters in the UK

The UK's Net Zero Strategy called for establishing four CCUS clusters, capturing between 20 and 30 Mt of CO_2 in total annual emissions, of which 6 Mtpa of CO_2 come from industrial sources by 2030. The strategy acknowledges that while clusters account for approximately half of industrial emissions, they could also help with decarbonisation goals by making use of existing technological and infrastructure development. They can also access government support through the CIF discussed in the earlier section.

In 2020, the UK Government entered a consultation process and set up a process called CCUS Cluster Sequencing. To be executed in two phases, the process prioritises cluster locations in phase one and allocates support in phase two (HM Government, 2021b). In the first phase, two clusters were identified - the East Coast Cluster and the HyNet Northwest Cluster. Both clusters have several international project partners. As part of the Hynet Northwest cluster, a CCS project from Hanson Padeswood Cement Works is being supported.

Since the clusters are required to be in the UK, the participating organisations are required to establish their projects in the UK. It is notable that while all projects in the two clusters are in the UK, several partners and supporting organisations are international companies (Department for Business Energy and Industrial Strategy and HM Government, 2021a).

While expressions of interest for Phase 1 of the cluster sequencing closed in May 2021, a shortlist of Phase 2 projects were released in August 2022 and will pass on to the due diligence stage of the cluster sequencing process. A total of 20 projects were selected in the hydrogen, power CCUS, and industrial carbon capture sectors.

As part of the cluster's development, the government has pledged a £1 billion Carbon Capture and Storage Infrastructure Fund. This fund aims to cultivate T&S networks, serving as the foundational infrastructure for various capture initiatives. Please refer to section 2.3.2 Specific Incentives for more detail on the fund (Department for Business Energy and Industrial Strategy and HM Government, 2022). Outside of the government-backed clusters, a consortium comprising Progressive Energy, Tarmac, Breedon, Lhoist, Aggregate Industries, and Lostock is spearheading the development of a CCS cluster known as the Peak cluster. This collaborative effort aims to significantly mitigate emissions from the cement and lime industry across Derbyshire, Staffordshire, and Cheshire. The project's focal point involves storing CO_2 in the depleted Morecambe gas field, with an anticipated reduction of over 3 Mt of CO_2 emissions starting from 2030 (Peak Cluster, no date).

4.3.5.2 Facilitating CCUS Hubs

The establishment of CO_2 transport infrastructure is pivotal for the widespread implementation of CCUS. It is imperative that existing or new frameworks facilitate the expansion of transport infrastructure and promote shared access. These frameworks should encourage and enable shared access to CO_2 transport infrastructure by delineating conditions under which operators must provide third-party access. For instance, projects receiving public funding may be mandated to offer third-party access. Additionally, frameworks should establish effective dispute resolution mechanisms to address any access refusals by operators or claims from potential new market entrants.

In the EU, the CCS Directive plays a pivotal role in overseeing the transportation of CO_2 to storage sites. Specifically, concerning pipeline transport, the directive mandates that member states ensure fair and transparent third-party access to both transport networks and storage sites. Operators hold the authority to deny access if the characteristics of the captured CO_2 are incompatible with the existing infrastructure or if genuine capacity constraints exist. However, operators are obligated to implement necessary enhancements to facilitate access in cases where denial stems from capacity limitations, provided such modifications are economically viable.

Similarly, the development of shared storage infrastructure can significantly stimulate CO_2 capture investment opportunities across various industrial sectors and regions. Frameworks should delineate

procedures for third-party access to shared storage infrastructure while considering the technical requisites for receiving and storing CO_2.

4.3.6 Issues of public acceptance

The level of public acceptance of CCUS can greatly influence the successful execution and economic viability of projects. Legal challenges from nearby communities can raise expenses, prolong timelines, or even result in project abandonment or relocation, as evidenced by early cases in the US. Consequently, it is imperative to include local stakeholders in project planning and decision-making processes. Moreover, facilitating knowledge dissemination about CCUS is crucial. Numerous studies indicate that individuals familiar with CCUS tend to acknowledge its climate-related advantages more readily than those who are not (Silvia Pianta, 2021).

4.3.6.1 EU – increasing public data availability and demonstration projects

At the EU level, policies and frameworks related to CCUS primarily emphasise the significance of public perception and engagement in the implementation of CCUS projects. However, these policies often delegate the operationalisation of such engagement to the Member States. Both the CO_2 Storage Directive and the carbon removals certification framework (CRCF) offer examples in this regard. The former suggests initiatives for CCS demonstration projects, encompassing a legal framework for public awareness measures, and underscores the need for making environmental information related to CO_2 storage publicly accessible. The latter makes reference to the Aarhus Convention (Regulation (EC) No 1367/2006), which mandates Member States and the EU to ensure public access to information by establishing rights for the public and imposing obligations on public authorities (EC CCUS Forum, 2023).

4.3.6.2 Canada – community engagement and public information sharing

Establishing effective public information channels becomes paramount for communicating the latest scientific and industrial advancements in this field. In-person communication has been widely employed for engaging the public in CCUS projects. For instance, the Shell Quest project in Canada successfully connected with communities and local stakeholders at open houses, “Quest Café” sessions and community events, and also established more enduring communication through platforms like the Community Advisory Panel (made up of local residents, the academic community, and representatives from local government and relevant authorities), allowing for ongoing discussions and issue-raising throughout the project implementation. The Panel provided, and continues to provide, a forum for stakeholders to provide input on the design and implementation of the project’s MMV plan (Government of Alberta, 2014).

Canada’s investment tax policy mandates that CCUS projects with eligible expenses exceeding CA$250 million must share project knowledge. A penalty of CA$2 million will be imposed for each required knowledge-sharing report that is not submitted. This initiative aims to enhance public accountability, expedite technology development, and foster collaboration (International CCS Knowledge Centre, no date).

4.3.6.3 US – studies to establish more effective policy interventions

In the United States, various studies have been conducted to gain insights into public perceptions surrounding technology, with the aim of informing policies and interventions to enhance its acceptance. A specific study, spanning four states, emphasised the pivotal role of information provision in shaping positive attitudes towards the technology. The research also underscored the importance of developing long-term policies for CCUS initiatives, cautioning that presenting it as an interim measure could negatively impact public perception.

The findings suggested that policies favouring bans on unabated power plants without carbon capture and storage received more favourable responses compared to subsidies for carbon capture and storage and taxes on unabated generation. Factors such as proximity to communities and the timing of implementation were also identified as influential in garnering public support (Silvia Pianta, 2021). While these studies do not establish a direct link between governmental policies and their outcomes, they provide valuable insights that can inform a proactive approach in designing effective policies.

5.0 INTERNATIONAL COLLABORATION TO ASSIST INDIA'S EFFORTS

5.1 Domestic stakeholders and collaboration

The Cement Manufacturers' Association (CMA) is the apex body of large cement plants in India, representing almost 75% of the total installed cement capacity. CMA endeavours to create an enabling business environment for the Cement Industry and is the Indian Cement Industries consolidated voice on policy matters and issues that impact the industry.

GCCA India was set up in July 2019 to work with Indian cement companies to drive sustainability and innovation projects. The purpose of GCCA India is to identify actions and facilitate steps for cement & concrete companies to accelerate progress towards sustainable development. Taking over the work of the Cement Sustainable Initiative (CSI) India (which formerly served as the sector's sustainability alliance), GCCA India focuses on driving forward the key sustainability work underway within the Indian cement sector.

GCCA India has developed a Work Program that focuses on the GCCA priorities but with practical application across the Indian built environment.

Key company members of GCCA include:

- Dalmia Cement, one of the leading cement manufacturers in the country, are exploring the adoption of CCUS technology, including the adoption of CCU for process emissions by 2040. The company plans to reach the level of –30 $kgCO_2$/ton by 2040, described as Dalmia-determined contributions (DDCs). To achieve this ambitious target, Dalmia Cement has announced the installation of a large-scale CCUS facility of capacity 0.5 Mtpa of CO_2 at one of its plants in Tamil Nadu, India.
- Heidelberg Materials a leader in CCUS development in the cement industry is also present in India.
- JK Cement is committed to reducing carbon emissions across its value chain. By 2030, they aim to reduce specific net scope-1 carbon emissions by 19.8% from the base year FY20. They are also part of the UNFCC's "Race to Zero" initiative, working towards net zero concrete production by 2050.
- JSW Cement is working on many levers as part of its decarbonisation roadmap contributing to its Net Zero roadmap by 2050. Last year JSW cement contributed to all three initiatives R100, EV100 and EP100 in one go. It also signed up to the UN energy compact setting a target of reaching 30% thermal substitution rate by 2030 (GCCA, no date).
- Orient Cement recognises its responsibility towards the planet and its people. It aspires to achieve the following targets by 2030: 25% thermal substitution rate (TSR), 50% of the total energy to come from renewable energy and Waste Heat Recovery System (WHRS) and a net zero target by 2070, aligning with the central governments ambition.
- UltraTech Cement is also exploring the use of CCS technology to reduce its carbon footprint. The company has announced plans to invest in CCS research and development, with the aim of developing a commercially viable CCS solution for the cement industry. UltraTech has entered partnerships with three start-ups shortlisted by GCCA (UltraTech, 2021).

Collaboration among key stakeholders could significantly advance CCUS projects within the cement industry. As discussed in the Outcome 1 report, implementing a hub-and-cluster model could be particularly advantageous. This approach would involve creating a cluster of cement plants that share CCUS infrastructure, thereby reducing the overall costs associated with implementation. Additionally, this model could attract private investment by enabling companies to charge fees for transportation and storage services.

The Outcome 1 report proposes potential options for cement clusters that could benefit from shared CO_2 storage infrastructure. While a tariff system offers a potential revenue model for transportation and storage operators, other revenue models outlined in Section 2 — including tax credits, loan guarantees, and direct funding — could also provide valuable financial support. In the future Outcome 3 report, the business model of flagship projects will be further explored.

5.2 International financing mechanisms

The mechanisms described below offer significant financial resources crucial for India to develop and implement CCUS projects. By utilising these funds and fostering international collaboration, India can expedite the adoption of CCUS technologies, reduce GHG emissions from its industrial and energy sectors, and advance its climate goals while promoting sustainable economic development. Many of these funding mechanisms are designed to support emerging economies in their energy transition, where securing financing is more challenging.

5.2.1 World Bank Funds

5.2.1.1 Clean Technology Fund (CTF)

This fund provides new, large scale financial resources to invest in clean technology projects in developing countries, which contribute to the demonstration, deployment and transfer of low carbon technologies with a significant potential for long-term GHG emissions savings (The World Bank, 2024).

5.2.1.2 International Finance Corporation

The International Finance Corporation (IFC) contributes to improving the socioeconomic conditions in developing countries by investing in private sector expansion. Its primary goal is to foster opportunities for individuals to break the cycle of poverty and attain higher living standards by mobilising financial resources for private enterprises, fostering accessible and competitive markets, supporting businesses, and generating employment (International Finance Corporation, no date).

Furthermore, the IFC is proactively engaging in creating markets for CCUS in the regions where it operates. It is actively building capacity among its clients to facilitate CCUS initiatives. Notably, the IFC is undertaking advisory projects in Nigeria and Timor-Leste.

In Nigeria, the focus lies on mapping emissions sources and geological storage locations to pinpoint potential hubs for CCUS activities. The project places special emphasis on industrial applications and also entails an assessment of the legal and regulatory landscape necessary for the industry's growth. In Timor-Leste, the IFC is aiding the government in crafting a legal and regulatory framework essential for the development of a geological site situated in the Timor Sea (IFC Climate and Sustainability, 2023).

5.2.1.3 World Bank CCS Trust Fund

The World Bank CCS Trust Fund (CCS TF), established in 2009 with funding from the UK and Norway, was concluded at the end of December 2023. Over its operational period, it allocated over US$55 million to CCUS programs in emerging and developing economies. Among its contributions, the CCS TF supported World Bank research initiatives in India (IEA, no date).

5.2.2 Asian Development Bank Capture and Storage Fund

The Asian Development Bank Carbon Capture and Storage Fund is a multi-partner trust fund established initially with the support of Australia under the Clean Energy Financing Partnership Facility. The UK joined in December 2012. The fund aims to accelerate the demonstration of carbon capture and storage technologies. All ADB member countries are eligible for funding, however India falls in the initial priority category (Asian Development Bank, 2024). It should be noted that the ADB CCUS Fund closed in 2022.

5.2.3 The Green Climate Fund

The Green Climate Fund is a financial mechanism of the UNFCCC and is a dedicated financing vehicle for developing countries. The fund has the capacity to deliver large scale infrastructure projects, including CCS, through several financial instruments, including grants, loan guarantees, concessional loans and equity investments (Green Climate Fund, 2024).

In mid-2024, the Green Climate Fund made its first investment in CCUS in Trinidad and Tobago. This investment will support the development of the country's national carbon capture and storage, including an assessment of storage potential in deep saline formations and the creation of a national storage atlas (IEAGHG, 2024).

5.2.4 United Nations Industrial Development Organisation

The United Nations Industrial Development Organisation (UNIDO) is an international entity dedicated to advancing industrial development with the goals of poverty reduction, fostering inclusive globalisation, and promoting sustainable development. UNIDO has actively contributed to bridging knowledge disparities in the practical application of carbon capture and storage by developing a comprehensive technology roadmap for carbon capture and storage implementation across diverse sectors (United Nations Industrial Development Organisation, no date).

5.2.5 International Carbon Markets – Article 6

Article 6 of the Paris Agreement provides a framework for countries to voluntarily collaborate in achieving their emission reduction targets outlined in their Nationally Determined Contributions (NDCs). Essentially, this allows a country (or a group of countries) to transfer carbon credits earned through GHG emission reductions to assist others in meeting their climate goals. Article 6.2 establishes the foundation for trading GHG emission reductions, or "mitigation outcomes," between nations. On the other hand, Article 6.4 is anticipated to resemble the Clean Development Mechanism from the Kyoto Protocol, creating a mechanism for trading GHG emission reductions under the oversight of the Conference of Parties (The World Bank, 2022).

During COP28, consensus on articles 6.2 and 6.4 was not reached, leading to their automatic deferral to the next round of negotiations. This delay, particularly for Article 6.4, postpones the establishment of an international carbon market mechanism. Persistent political issues revolve around the authorisation of credits and various transfer mechanisms, adding complexity to the ongoing negotiations (Global CCS Institute, 2023).

5.3 Global knowledge-sharing, acceleration and coordination efforts

India can leverage the international initiatives outlined below to accelerate CCUS efforts, particularly in high-emitting industries, such as cement. Various international efforts exist and would allow India to learn from other countries' experiences, accelerate CCUS deployment domestically and avoid having to "start from zero".

Through the Industrial Transition Accelerator, India can access expertise and funding for deploying CCUS technologies. The Cement and Concrete Breakthrough Initiative and Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (CEM IDDI) can help set industry standards and promote low-carbon materials, supported by public procurement policies. India would also be very welcome to join the Clean Energy Ministerial CCUS Initiative, allowing to draw from the experience of currently 15 countries across the world as regards CCUS deployment programmes and incentive policy frameworks. India's participation in Mission Innovation and potential involvement in the Carbon Management Challenge can further boost investment in CCUS technologies and foster knowledge exchange between countries. Additionally, the GCCA CCUS Handbook offers practical guidance for developing CCUS projects in the cement industry, while the Clean Energy Transition Partnership provides opportunities for collaboration and funding in clean energy innovations.

5.3.1 Industrial Transition Accelerator (ITA)

During COP28, the ITA was introduced to expedite the decarbonisation of high-emission sectors like energy, industry, and transportation, aiming to hasten the achievement of Paris-aligned goals. This initiative seeks collaboration among industry leaders, policymakers, and

financiers to stimulate investments and swiftly execute decarbonisation projects in these sectors, potentially incorporating Carbon Capture and Storage.

GCCA is leading the Cement & Concrete sector in a global COP presidency/UNFCC initiative aimed at developing an action plan, projects and other decarbonisation actions (Mission Possible Partnership, no date).

5.3.2 Cement and Concrete Breakthrough Initiative

This is a global effort launched at COP28. It aims to accelerate the development and deployment of technologies and policies necessary to achieve net-zero emissions from the cement and concrete industry by 2050. The initiative, co-led by Canada and the United Arab Emirates, is in its early stages, however it will work to share best practices on policies and measure to decarbonise the sectors, convene key stakeholders and support pilot projects. Although no funding has been confirmed with this initiative, in the future, it may provide some financial instruments to support CCUS cement projects (GCCSA, 2023).

5.3.3 G20 Presidency

India held the G20 Presidency in 2023, taking over from Indonesia in December 2022, presiding through the end of November 2023 (COP28 start date) (G20 Secretariat, Ministry of External Affairs and Government of India, 2023a; United Nations Climate Change, 2023). Climate change and a just transition were high on the agenda during this period. Climate finance will be important for India to achieve its climate goals (G20 Secretariat, Ministry of External Affairs and Government of India, 2022, 2023b). The Government acknowledged this and indicated in a primer that CCUS could contribute to meeting India's climate and energy goals (G20 Secretariat, Ministry of External Affairs and Government of India, 2022).

5.3.4 Clean Energy Ministerial

The Clean Energy Ministerial (CEM) is a prominent global clean energy implementation platform, with 30 member countries and governments from across the world. Through its numerous work streams, CEM accelerates the dissemination of policies and initiatives that propel the advancement of clean energy technologies. By facilitating the exchange of best practices and fostering collaboration, CEM endeavours to drive the transition toward a global clean energy economy. India is a full member of the CEM and hosted the 14th Clean Energy Ministerial meeting in Goa in July 2023. The following two CEM work streams can be particularly relevant as regards advancing CCUS in the cement sector.

5.3.4.1 CEM CCUS Initiative

With its 15 government members, the CEM CCUS Initiative is a leading global government-to-government platform to exchange best practice on CCUS strategy and policy. In addition to peer-to-peer exchanges, CEM CCUS Initiative works closely with both industry and the finance sector to foster investment opportunities across several sectors. In particular, the CEM CCUS has a close working relationship with GCCA. Several joint workshops have been organised in 2023-2024, to discuss issues such as incentive policies, CO_2 infrastructure build-out and project financing.

India is not yet a CEM CCUS Member, but the door is open for India to join at any time (Clean Energy Ministerial, no date a).

5.3.4.2 CEM Industrial Deep Decarbonisation Initiative (IDDI)

Low carbon procurement schemes for cement and concrete aim to reduce GHG emissions associated with the production and use of these materials. These schemes typically involve collaboration between industry stakeholders, governments, and international organisations to promote the adoption of low-carbon materials.

The IDDI is a global coalition of public and private entities collaborating to stimulate global demand for low-carbon industrial products, such as cement and steel. The UNIDO coordinates the IDDI. Co-led by the UK and India. Current members of IDDI are Canada, Germany, India, Saudi Arabia, Sweden, UAE, the US, the UK and Brazil.

The IDDI green procurement pledge includes government commitments to procure low or near-zero emissions steel, cement, and concrete for public construction projects. For cement and crude steel, IDDI has used the IEA methodology as a robust starting point for setting bands and defining low-carbon product. For concrete, a methodology by GCCA in collaboration with IDDI is proposed, however as of today, this has not been endorsed, adopted or used by IDDI (Clean Energy Ministerial, no date b).

5.3.5 Mission Innovation

Mission Innovation is a global initiative catalysing a decade of action and investment in research, development and demonstration to make clean energy affordable, attractive and accessible for all. This will accelerate progress towards the Paris Agreement goals and pathways to net zero. Mission Innovation has provided support to advance CCS, including the previous "Carbon Capture Challenge", that aimed to foster research development and implementation of innovative technologies that enhance CCUS practices (Mission Innovation, no date).

Mission Innovation currently has the Carbon Dioxide Removal Mission ("MI CDR Mission"), bringing together nine governments to jointly accelerate innovation in the area of technological carbon dioxide removal via technologies such as Biomass Carbon Removal and Storage (BiCRS), Direct Air Capture (DAC) and Enhanced Mineralisation (EM). India participates in the MI CDR Mission.

5.3.6 Carbon Management Challenge (CMC)

The CMC stands as a collective initiative and global call to action, uniting countries in an effort to expedite the implementation of carbon capture, removal, utilisation, and storage technologies. The CMC was launched at the Major Economies Forum in April 2023, and participants currently include 21 nations and the European Commission.

Acknowledging the imperative to limit warming to 1.5°C with minimal overshoot, the initiative seeks to significantly accelerate the deployment of carbon management technologies and infrastructure, viewing them as essential complements to the adoption of other zero-carbon technologies and energy efficiency measures.

The objective of the CMC is to enhance ambition by fostering a global commitment to advance carbon management projects on a gigaton scale by 2030. Governments involved in the Carbon Management Challenge may take various actions, including advocating for supportive policies, showcasing progress in CCUS demonstrations, establishing national targets for carbon capture deployment and removal projects by 2030, and contributing resources/funding to carbon management initiatives. It is important to note that India is not currently part of this coalition (Carbon Management Challenge, 2024).

5.3.8 Clean Energy Transition Partnership (CETPartnership)

The CETPartnership, co-funded by the European Union, serves as a collaborative platform uniting both public and private stakeholders within research and innovation ecosystems across European and non-European regions. Its primary objective is to cultivate transnational innovation ecosystems and bridge gaps in fragmented research and innovation landscapes.

Transition Initiatives (TRIs) within the CETPartnership represent collaborative configurations of members focused on addressing specific thematic challenges. TRI 3 is particularly centred on advancing technological solutions for cleaner storage technologies, hydrogen and renewable fuels, carbon capture and storage, and CCU. The TRI 3 group aims to support projects that significantly accelerate these technologies and demonstrate substantial CO_2 reduction by 2030, thereby contributing to achieving climate neutrality by 2050 (CET Partnership, no date).

5.3.7 GCCA CCUS Handbook

GCCA developed for the benefit of its members a CCUS Handbook which building on current experiences assist companies in developing their CCUS projects. The Handbook is meant to address all questions to be considered when developing a CCUS project. As with any large-scale development, cost and complexity are variable. Based on feasibility studies in CCUS for cement manufacturing and study of existing CCUS projects, there are several key decisions that affect potential outcomes throughout the value chain.

While many organisations start with technology selection, it is important to consider all the aspects and costs surrounding the development of a carbon capture solution when making a project decision. The necessary information to consider includes the type of fuel, such as coal/coke, natural gas, biofuel, the composition of flue gas, technology selection, site selection, transportation, storage and utilisation and project financing will all impact the economic feasibility for the project.

6.0 CONCLUSION

India showcases significant potential for the implementation of CCUS within its cement industry. The impending establishment of a domestic carbon market presents an opportunity to enhance the economic viability of low-carbon alternatives like CCUS, bolstered by activities from the National Centre of Excellence and the Department of Science and Technology that drive technological innovation.

However, despite notable strides, the absence of specific governance poses a challenge to creating an enabling environment for CCUS adoption in the cement sector. Particularly, the lack of comprehensive legal and regulatory frameworks for CCUS is a critical gap, essential for ensuring the safe storage of CO_2. The Indian government should prioritise the establishment of suitable regulations, which could take the form of amending existing legislation or enacting stand-alone CCS-specific legislation, to regulate CCUS activities effectively.

From a policy standpoint, while the introduction of a domestic carbon market is a positive step towards incentivising decarbonisation technologies, additional measures such as subsidies or tax incentives may be necessary, especially considering the anticipated low carbon prices in the initial stages. India's current landscape lacks substantial financial incentive schemes to drive CCUS deployment.

Moreover, the government could leverage its influence as a major consumer of cement to boost the market appeal of net-zero or low-carbon cement. By implementing policies or green procurement standards favouring such products, the government could stimulate demand, encouraging cement producers to adopt CCUS technologies.

Furthermore, by leveraging its domestic institutions and participating in global collaboration initiatives, India can facilitate knowledge sharing and innovation, ultimately driving down the costs associated with CCUS implementation, and ensuring the competitiveness of cement producers.

As emphasised in the previous report, India's expedited transition from coal to renewables is paramount. By accelerating ongoing initiatives in this direction, the government can solidify CCUS as a viable tool for decarbonising the Indian cement industry.

7.0 APPENDIX

7.1 Existing regulations relevant to the cement industry

7.1.1 Manufacturer, Storage and Import of Hazardous Chemicals Rules, (1989)

The "Manufacturer, Storage and Import of Hazardous Chemicals Rules, 1989" in India primarily focuses on regulating the storage and handling of hazardous chemicals. Key elements related to storage and licensing include: 'Entities dealing with hazardous chemicals must comply with specific storage standards outlined in the rules'. These standards encompass safety measures, infrastructure, and protocols to prevent accidents, leaks, or spills. Industries involved in the storage of hazardous chemicals are required to obtain the necessary licenses from regulatory authorities. These licenses ensure that the storage facilities adhere to prescribed safety standards and comply with environmental and health regulations (The Manufacture, Storage, and Import of Hazardous Chemical Rules, 1989, 1989).

7.1.2 Air (Prevention and Control of Pollution) Act, (1987)

The Air (Prevention and Control of Pollution) Act was enacted in 1981 and amended in 1987 to provide for the prevention, control and abatement of air pollution in India. Air pollutant is any solid, liquid, gaseous substance in such concentrations as may be injurious to human beings, living creatures, plants, property or the environment. Every cement plant has to obtain consent to establish/operate from the respective State Pollution Control Boards (SPCBs) at the commissioning stage, and subsequent years of production.

Some of the strict conditions imposed are given below:

- Limit on maximum quantity of production of cement/ cement clinker/limestone.
- Conditions on appropriate air pollution control equipment provided with dust generating units.
- Condition regarding type and quantity of fuel used.
- Condition pertaining to flue gas stack height.
- Condition pertaining to emissions of air pollutants.
- Condition pertaining to concentration of pollutants in ambient air.
- Condition pertaining to regular monitoring of stack emissions and ambient air quality(Air Pollution Act, 1987, no date)

7.1.3 Environment Protection Act (1986)

The Environment Protection Act was enacted in 1986 with the objective of providing for the protection and improvement of the environment. It empowers the central government with the mandate of preventing environmental problems that are peculiar to different parts of the country. The Act follows the polluter pay principle, which holds that the cost of environmental pollution should be borne by the polluter. The powers conferred by the Act and its subsequent amendments are followed under the headings given below:

- Coastal regulation zone.
- Environmental clearance – general.
- Eco-marks scheme.
- Eco-sensitive zone.
- Environmental labs.
- Environmental standards.
- Hazardous substances management.
- Loss of ecology.
- Noise pollution.
- Water pollution.
- Ozone layer depletion(World Cement , 2013).

In India, the Environmental Impact Assessment (EIA) is a regulatory process that assesses the potential environmental impacts of proposed developmental projects or activities. The process is governed by the environment assessment notification, 2006, issued under the Environment (Protection) Act, 1986. Cement and mining projects fall under the notification and are classified into category A and B.

In Category A, an Environmental Impact Assessment (EIA) is obligatory, necessitating the acquisition of environmental clearance from the Ministry of Environment, Forest, and Climate Change. On the other hand, Category B projects undergo evaluation and clearance procedures facilitated by the state environmental impact assessment authority (SEIAA). Within Category B, projects are further categorised as B1 or B2 by the state authority. B1 projects mandate the preparation of an EIA report, while B2 projects do not require such a report. Cement projects in India commonly fall under Category A. Project proponents are required to prepare a detailed EIA report to the regulatory authority. Public consultations constitute an essential element of the process, encompassing the dissemination of project-related information to the public. These consultations are usually conducted both at the project site and in areas directly affected by the proposed project (Centre for Science and Environment, 2024).

7.1.4 The Water (Prevention and Control of Pollution) Cess Act, (1977)

The Water (Prevention and Control of Pollution) Cess Act (referred to as the Cess Act) was enacted in 1977 to provide for the levy and collection of a tax on water consumed by persons operating and carrying out certain types of industrial activities. This is collected with a view to augment the resources of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974. The Act was last amended in 2003. Every cement plant has to submit the annual returns of water consumption to the respective SPCB and pay tax on the basis of water consumption (World Cement, 2013).

7.1.5 The Forest (Conservation) Act, (1980)

The Forest (Conservation) Act, 1980, amended in 1988, was enacted to restrict the indiscriminate diversion of forest land to non-forest purposes. Under this act, prior approval of central government is required before any reserved forest is declared as de-reserved or diverted to non-forest purposes. If diversion is permitted, compensatory forestation is insisted upon, and other suitable conditions imposed where non-forest lands are not available. For the cement industry, when any forest area is diverted for cement facilities or CCS pipelines, the provisions of the Forest Act must be implemented. Proper compensatory afforestation is required as per the conditions of this act (Forest (Conservation) Act, 1980 with amendments made in 1988, 2005).

7.1.6 Bureau of Indian Standards

The Bureau of Indian Standards (BIS) has implemented various Indian Standards (IS) for diverse types of cement, encompassing their physical, chemical, and performance attributes. These standards play a crucial role in ensuring a consistent level of quality and safety for the cement used in construction projects.

Operating within the framework of the Conformity Assessment Scheme (CAS), BIS administers a product certification scheme for cement. Manufacturers that adhere to the relevant IS standards are eligible to receive the prestigious BIS Mark, signifying a commitment to quality and reliability for consumers. Under the Cement (Quality Control) Order, 2003, the manufacturing, selling, and distribution of cement that does not comply with BIS standards and lacks the standard mark is prohibited.

Looking ahead, there is potential for BIS to institute a certification scheme for cement based on embodied carbon performance. This would serve as a compelling incentive for manufacturers to explore and adopt low-carbon technologies, further contributing to environmentally sustainable practices in the industry (Cement Standards, 2024).

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CARBON CAPTURE, UTILIZATION & STORAGE
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