



REGULATORY GAPS AND CHALLENGES WITH LARGE-SCALE CCUS DEVELOPMENT: DISPARITY BETWEEN ADVANCEMENTS IN CCS AND CCU

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Carbon capture, utilization and storage (CCUS) technology is critical for achieving climate goals and transitioning to a low-carbon economy. So, while efficiency measures and renewable energy are important, CCUS will be essential for decarbonizing hard-to-abate sectors and achieving net-zero emissions. However, it is important to differentiate between two important terminologies related to CCUS, namely, carbon, capture and storage (CCS) and carbon capture and utilization (CCU). The regulatory framework to develop CCS is increasing around the world, and Brazil recently advanced in this area with the enactment of Law No. 14.993, which establishes specific regulations for CCS activities in the country. However, the situation with CCU is quite different, as there is a critical regulatory gap in developing CCU globally. The paper adopts the use of doctrinal research and case study analysis. In so doing, it begins by outlining the interrelation between CCUS, CCS, and CCU, as well as the primary legal and financial barriers to their implementation. It proceeds to highlight the disparity between advancements in the development of the different aspects of CCUS, and adopts Brazil as a case study. The authors conclude with a set of recommendations for policymakers. These include developing comprehensive legal and regulatory frameworks, investing in research and development, promoting public awareness and engagement, accessing financial challenges and funding opportunities, and establishing technical committees to oversee implementation. They argue that while addressing these legal and policy barriers is challenging, it is essential for enabling large-scale CCUS deployment to meet climate goals.

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1. INTRODUCTION

With the growing global climate agenda, the prevention of carbon from being released to the atmosphere is a significant approach to cutting down global emissions.¹ Over the last decade, carbon capture, utilisation and storage (CCUS) has continued to receive heightened global interest in this regard. CCUS refers to a group of technologies that enhance climate objectives in a variety of ways. It involves the capture of CO₂ from sources that use fossil fuels or biomass, or direct carbon capture from the atmosphere.² If not used on site, captured CO₂ is compressed and transported to be used in other industrial applications, or injected into geological formations or into gas reservoirs. In other words, CCUS represents a key technique for achieving decarbonization through the process of capturing carbon dioxide (CO₂) emissions from fossil power generation and other industrial processes either for storage deep underground, or re-use.³ More importantly, CCUS technology can provide a means of removing CO₂ from the atmosphere to offset emissions from sectors where reaching zero emissions may not be economically or technically feasible.⁴

The largest contribution to the global greenhouse effect and climate change stems from CO₂ emissions.⁵ The Paris Agreement of 2015 has endorsed international decarbonisation efforts, especially through Article 2 requiring signatories to pursue efforts to keep global warming to 1.5 degree Celsius above pre-industrial levels of warming. Since carbon capture constitutes a mechanism for carbon emissions reduction, it is an important tool for combating climate change and enhancing the climate agenda.⁶ Hence, member-States of the United Nations Framework Convention

¹ International Energy Forum, 'What Is CCUS and Why Is It Necessary' (20 July 2021) <https://www.ief.org/news/what-is-ccus-and-why-is-it-necessary> accessed 24 December 2024

² International Energy Forum, 'Carbon, Capture, Utilisation and Storage' <https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage> accessed 24 December 2024

³ Global CCS Institute <http://www.globalccsinstitute.com>

⁴ International Energy Agency, 'CCUS in Clean Energy Transitions: A New Era for CCUS' <https://www.iea.org/reports/ccus-in-clean-energy-transitions/a-new-era-for-ccus> accessed 1 November 2024.

⁵ M Steen, *Greenhouse Gas Emissions from Fossil Fuel Fired Power Generation Systems* (European Commission Joint Research Centre) 5

<https://publications.jrc.ec.europa.eu/repository/bitstream/JRC21207/EUR%2019754%20EN.pdf> accessed 1 November 2024.

⁶ Carbon Gap, *The Difference between CCS, CCU and CDR – and Why It Matters* <https://carbongap.org/wp-content/uploads/2022/11/The-difference-between-CCS-CCU-and-CDR-and-why-it-matters.pdf> accessed 1 November 2024.

on Climate Change and signatories to the Paris Agreement, have increasingly involved themselves in research concerning CCUS and its development.⁷

As per the name, CCUS apparently encompasses different aspects including carbon capture and storage (CCS), and carbon capture and utilisation (CCU). CCS is a process of capturing CO₂ from stationary sources of carbon emissions before it is released into the atmosphere, and long-term geologic storage such captured CO₂,⁸ or capturing atmospheric CO₂, either directly from air (hereafter referred to as direct air capture, DAC) or from a point source (e.g. a large fossil fuel-powered thermal power plant), and then injecting it in the subsurface for geologic storage.⁹ CCU refers to the reuse or utilization of captured or stored CO₂ in other applications. It is therefore noteworthy that the success of CCUS in the ongoing climate agenda will largely depend on how much of CO₂ emitted is captured from different point sources, as well as whether and how the captured CO₂ is treated, and the subsurface characterization of target injection and confining zones.

This paper is divided into seven sections. The first section provides an introduction to the paper. The second section presents an analysis of the different aspects of CCUS including CCS and CCU. The third section analyses the various challenges involved with the development of CCUS, ranging from financial challenges to the lack of a robust legal framework. The fourth section examines recent developments on specific important aspects of the CCUS process including CCS and CCU, and pinpoints the lack of regulations in place for developing CCU. While section five presents a case study to highlight these developments, section six presents a brief overview of the lessons learned. The paper concludes that CCU is a very significant aspect of CCUS and adequate CCU development can contribute positively to the large-scale development of CCUS. Hence, the final section of the paper offers some recommendations for the development of CCU globally.

2. CCS AND CCU

CCS and CCU are both long-term techniques intended to combat climate change, as they are necessary on the way to reach large-scale reduction of CO₂ emissions as

⁷ UNFCCC, <https://unfccc.int/> accessed 1 November 2024.

⁸ T Wilberforce, AG Olabi, ET Sayed, K Elsaid and MA Abdelkareem, 'Progress in Carbon Capture Technologies' (2021) 761 *Sci Total Environ* 143203 <https://doi.org/10.1016/j.scitotenv.2020.143203>.

⁹ LN Nazarian and others, 'Imaging Algorithms for Evaluating Suspected Rotator Cuff Disease: Society of Radiologists in Ultrasound Consensus Conference Statement' (2013) 267 *Radiology* 589; FO Pires and others, 'The Influence of Peripheral Afferent Signals on the Rating of Perceived Exertion and Time to Exhaustion during Exercise at Different Intensities' (2011) 48 *Psychophysiology* 1284–90.

quickly as possible.¹⁰ While CCS and CCU are methods of the broader family of ‘carbon management’, they have different impacts on climate change and different roles in the climate agenda due to the crucial divergence in how captured CO₂ is handled.¹¹

- **Carbon Capture and Sequestration/ Storage (CCS)**

CCS is the separation of CO₂ from industrial exhausts coupled with the permanent geological storage of that carbon.¹² CCS is a way of reducing carbon emissions, through the deployment of technologies that prevent CO₂ from getting released into the atmosphere by capturing it at the source of emission and storing it safely so that it does not contribute to climate change. It involves three steps: carbon capture, whereby CO₂ is separated from other gases produced at the point of emission; post-capture, whereby the captured CO₂ is compressed and transported from the point of emission; and storage, whereby the captured CO₂ is dehydrated and sent to a storage site. With CCS, captured CO₂ is usually permanently injected into rock formations within saline aquifers or depleted oil and gas reservoirs for storage.¹³ CCS has been used to prevent up to 40 million tons of CO₂ per year from escaping into the atmosphere.¹⁴

- **Carbon Capture and Utilization (CCU)**

CCU is a part of carbon recycling applications that deals with the reuse of captured carbon either directly or as an ingredient in new products.¹⁵ With CCU therefore, CO₂ is removed from the atmosphere and placed in a closed loop for utilization. Such utilization deals with the process of converting captured CO₂ into a resource to make

¹⁰ Neste, ‘CCS and CCU. Mind Explaining What These Are Again?’ <https://www.neste.com/news-and-insights/circular-economy/ccs-and-ccu-mind-explaining-what-these-are-again> accessed 1 November 2024

¹¹ Carbon Gap, *The Difference between CCS, CCU, and CDR – and Why It Matters* <https://carbongap.org/wp-content/uploads/2022/11/The-difference-between-CCS-CCU-and-CDR-and-why-it-matters.pdf> accessed 1 November 2024

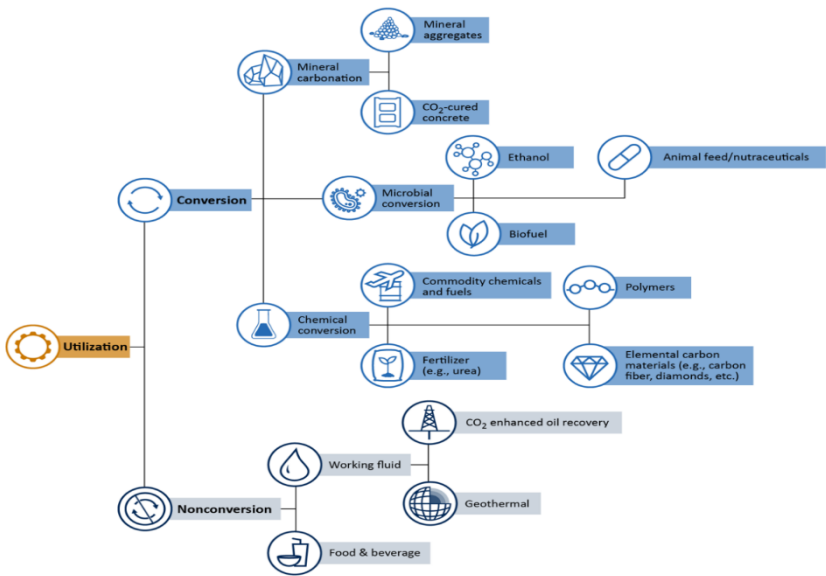
¹² Ibid.

¹³ Net Zero Cities, ‘Carbon Capture and Storage (CCS) and Utilisation (CCU)’ <https://netzerocities.app/resource-3318> accessed 1 November 2024.

¹⁴ Neste (n 10)

¹⁵ Carbon Gap (n 11)

value-added products. Carbon utilization technologies can be divided into chemical technologies, biological technologies, and mineralization processes.¹⁶



Utilization of CO2 via CCU methods

Source: GAO-22-105274

Utilization as shown in the figure above can be done through various modes of carbon repurposing. For instance, captured carbon may be utilized directly on-site in other applications such as enhanced oil recovery (EOR), or used in a range of other industrial applications such as power generation and low-carbon hydrogen production, among others, thereby reducing atmospheric carbon concentrations. CO2 utilization therefore constitutes a significant tool for managing carbon flows and ensuring that sought-after products can be made sustainably.¹⁷ Utilization of CO2 also holds relative financial

¹⁶ Reza Mahmoudi Kouhi and others, ‘Carbon Utilization Technologies & Methods’ in Ali Ahmadian, Ali Elkamel and Ali Almansoori (eds), *Carbon Capture, Utilization, and Storage Technologies: Towards More Sustainable Cities* (Springer 2024) 1–50.

¹⁷ National Academies of Sciences, Engineering, and Medicine, *Carbon Utilization Infrastructure, Markets, and Research and Development: A Final Report* (The National Academies Press 2024) <https://doi.org/10.17226/27732>.

benefits in that the cost of establishing CCS plants, which demand high capital investment, is greatly reduced.¹⁸ Meanwhile, CO₂ utilization could also stimulate growth in areas along food industries, oil and gas recovery, medical sciences, and usage of captured CO₂ as a form of solvent in industries.¹⁹ In other words, CO₂ utilization holds significant potential climate benefits and market opportunities. Beyond CCS therefore, CCU portends a more significant aspect of sustainable development; while CCS may contribute immensely to emissions reduction, CCU holds the potential to contribute to emissions reduction while improving socio-economic development.

3. CHALLENGES BEHIND THE DEVELOPMENT OF CCUS

Despite recognition of their unique role in decarbonization, the deployment of these technologies has been slow, with less than 0.5% of annual global investment in clean technologies being allocated to CCUS, and therefore with limited impact on global CO₂ emissions.²⁰ The major challenges inhibiting the large-scale deployment of CCUS include financial, commercial and regulatory barriers.

Lack of robust legal and regulatory frameworks on the different aspects of CCUS pose a significant challenge to the large-scale development of CCUS globally. CCUS regulatory frameworks are expected to consider all aspects of the CCUS value chain, ranging from capture, to transportation, usage, and storage.²¹ The storage of CO₂ has however been the primary focus, as it presents novel and complex issues for regulations. CCS portends significant challenges particularly regarding the ownership, stewardship and liability for CO₂ that is to be stored in perpetuity. This is in addition to the challenge with the choice of appropriate and safe storage sites for captured CO₂.²²

The regulatory challenges concerning CCUS regarding stages of CO₂ capture, transport, and use arise due to the overlap with the scope of existing regulatory

¹⁸ Michel Moreaux and others, 'Carbon Capture: Storage vs. Utilization' (2024) 125 J Environ Econ Manage 102976 <https://doi.org/10.1016/j.jeem.2024.102976>.

¹⁹ Net Zero Cities, 'Carbon Capture and Storage (CCS) and Utilisation (CCU)' <https://netzerocities.app/resource-3318> accessed 1 November 2024.

²⁰ International Energy Agency, *CCUS in Clean Energy Transitions: A New Era for CCUS* (IEA 2021) <https://www.iea.org/reports/ccus-in-clean-energy-transitions/a-new-era-for-ccus> accessed 29 October 2024.

²¹ IEA, *Legal and Regulatory Frameworks for CCUS: An IEA CCUS Handbook* <https://iea.blob.core.windows.net/assets/bda8c2b2-2b9c-4010-ab56-b941dc8d0635/LegalandRegulatoryFrameworksforCCUS-AnIEACCUSHandbook.pdf> accessed 1 November 2024.

²² Ibid.

frameworks for industrial activities, which include oil and gas, waste management, health, safety and environmental considerations for industrial sites, property rights, and transport.²³ However, this requires little modification to existing frameworks compared to CO₂ storage, where the level of modification is more variant.

Moreover, the regulatory approach to deployment of CCUS has changed since the enactment of the 2010 Model Regulatory Framework by the International Energy Agency (IEA).²⁴ Now, regulation is more complex, with the regulation having moved beyond single-chain projects and instead target industrial clusters and storage hubs. These hubs can pose a range of legal and regulatory issues related to network access, and international and transboundary legal considerations if transport or storage infrastructure spans multiple jurisdictions.²⁵

Policymakers and regulators also face challenges in the planning and development stage of CCUS laws. Certain considerations need to be clarified before moving forward with the legislation concerning CCUS. For example, the role of CCUS in meeting national energy and climate goals must be clarified. It needs to be ascertained that the laws fit with the legal frameworks already in place. Further, complementary guidelines should be in place to address contingent issues such as long-term CO₂ storage liability. Key stakeholders and rightsholders should be engaged early in the planning process. Process to review and amend the legal framework should be mentioned within the framework itself. Likewise, governments need to establish regulatory authorities with sufficient resources to oversee and properly regulate the CCUS activities.

Further in many jurisdictions, there is also a gap in regulation, especially concerning CO₂ utilization. CO₂ utilization has an important role to play in ascertaining the future of net-zero emissions economy by providing a foundation that is sustainable for carbon-based products.²⁶ Therefore, a regulatory framework should be in place addressing the process and scope of CO₂ utilization. The utilization or even

²³ Ibid.

²⁴ IEA, *Carbon Capture and Storage: Model Regulatory Framework* (IEA 2010) <https://www.iea.org/reports/carbon-capture-and-storage-model-regulatory-framework>.

²⁵ IEA, *Legal and Regulatory Frameworks for CCUS: An IEA CCUS Handbook* (IEA 2024)

<https://iea.blob.core.windows.net/assets/bda8c2b2-2b9c-4010-ab56-b941dc8d0635/LegalandRegulatoryFrameworksforCCUS-AnIEACCUSHandbook.pdf>

²⁶ National Academies of Sciences, Engineering, and Medicine, *Carbon Utilization Infrastructure, Markets, and Research and Development: A Final Report* (The National Academies Press 2024) <https://doi.org/10.17226/27732>.

development of its infrastructure will require fundamental changes to current policy and regulatory structures.²⁷

Additionally, advancements along utilization have struggled to be in place mainly due to the challenges faced by CCUS itself. CCUS technology is high in costs,²⁸ there is a lack of infrastructure within countries catering to CCUS,²⁹ and the issues circulating around the public perception regarding CCUS.³⁰ Aside the initial capital-intensive investments in CCUS technologies, subsequent operational risks of CCUS may result in long-term operating and maintenance costs. Therefore, there is a critical role for financing in determining the success of CCUS development. For instance, an estimated \$2.4 trillion annual investment is required to scale up investment in climate action in the energy sector alone.³¹ This high upfront capital cost has led to CCUS being exclusive to the global north, with developed countries exhibiting a stronger economic ability to incentivize the establishment of CCUS industries in their territories. Thus, financial barrier poses a major challenge to the development of CCUS, especially for developing countries. There is a further challenge regarding the economic and social viability of CCU particularly in the absence of policy incentives. According to the Nacional Agency of Petroleum, Natural Gas and Biofuels (ANP), the costs associated with CCUS applications and the lack of predictability regarding revenue streams are major obstacles to the large-scale development of this activity.³² Firstly, the oil and gas industry's experience with EOR has significantly influenced the initial business model for the CCUS chain, resulting in a high degree of vertical integration. Nevertheless, this model requires extensive technical and operational expertise across all project phases, leading to high capital expenditures (CAPEX) and elevated risks. Consequently, this approach is challenging for other emitters to replicate.

²⁷ Ibid.

²⁸ IEA, *Energy Technology Perspectives 2015: Mobilising Innovation to Accelerate Climate Action* (IEA 2015).

²⁹ Fiona Bowen, 'Carbon Capture and Storage as a Corporate Technology Strategy Challenge' (2011) 39 *Energy Policy* 2256–2264; A Babin, C Vaneeckhaute and M C Iliuta, 'Potential and Challenges of Bioenergy with Carbon Capture and Storage as a Carbon-Negative Energy Source: A Review' (2021) 146 *Biomass Bioenergy* 105968.

³⁰ IEA, *Energy Technology Perspectives 2020* (International Energy Agency 2020).

³¹ Vera Songwe, Nicholas Stern and Amar Bhattacharya, *Finance for Climate Action: Scaling Up Investment for Climate and Development* (Grantham Research Institute on Climate Change and the Environment, LSE 2022).

³² Agência Nacional do Petróleo, *Relatório de Implementação do Marco Regulatório de Carbon Capture, Use and Storage – CCUS* (2024) https://www.gov.br/anp/pt-br/canais_atendimento/imprensa/relatoriocusstm24.04.09.pdf accessed 29 October 2024.

A recent study by the IEA indicates that vertical integration may not be suitable for the CCUS applications necessary for achieving emission neutrality.³³ This is particularly relevant for applications where CO₂ is not separated as part of the process, necessitating dedicated capture equipment. The study emphasizes the importance of new business models with greater segmentation of suppliers and the establishment of CCUS hubs. These hubs aim to reduce connection times to shared infrastructure and distribute costs among participants, facilitating the integration of smaller emitters. In addition, the study also highlights the need for incentive policies to boost the economic viability of CCUS projects, especially demand-side policies to encourage the market for low-emission products.³⁴ The significance of such policy incentives can be deduced from the acceleration in CCUS initiatives in the past two years. For instance, the U.S. Inflation Reduction Act (IRA) provided a critical update to the 45Q tax credit regime to incentivize carbon capture projects³⁵, while similar funding initiatives are present in Australia, Canada, China, and the European Union.³⁶ These policies have been crucial in advancing CCUS projects in these countries.

Overall, the various regulatory, commercial, and financial challenges associated with the different aspects of CCUS underscore the need for comprehensive regulatory policies, innovative commercial approaches, and financial mechanisms to support the development of CCUS technologies and CCUS value chains, ensuring their sustainability, economic viability and scalability.

4. GLOBAL ADVANCEMENTS IN CCUS: DISPARITY BETWEEN CCS AND CCU

There lies an abundant extent of knowledge gaps and technical barriers and need to be addressed to advance CO₂ utilization technologies.³⁷ The American Report on Carbon Utilization provides that there is a lack of research on matters concerning the

³³ Agência Internacional de Energia, IEA, *CCUS Policies and Business Models: Building a Commercial Market* (IEA, 2023) <https://www.iea.org/reports/ccus-policies-and-businessmodels-building-a-commercial-market> accessed 09 November 2024

³⁴ Ibid.

³⁵ Clean Air Task Force, 'Carbon Capture and the Inflation Reduction Act' (2023) <https://cdn.catf.us/wp-content/uploads/2023/02/16093309/ira-carbon-capture-fact-sheet.pdf> accessed 9 November 2024.

³⁶ Clean Energy Ministerial, 'Global Developments with CCUS Deployment Programmes' (2023) <https://www.cleanenergyministerial.org/content/uploads/2023/07/global-developments-with-ccus-deployment-programmes.pdf> accessed 9 November 2024.

³⁷ National Academies of Sciences, Engineering, and Medicine, 'New Report Lays Out Role for Carbon Dioxide Utilization in U.S. Economy, Identifies Research Gaps and Opportunities' (2024) <https://www.nationalacademies.org/news/2024/08/new-report-lays-out-role-for-carbon-dioxide-utilization-in-us-economy-identifies-research-gaps-and-opportunities> accessed 1 November 2024.

environment, market, resource, and workforce of CO₂ utilization,³⁸ which will not incentivize the furtherance of the process. Further, there is a lack of public awareness, with the public being unaware of the carbon management opportunities, needs, risks, and benefits.

In 2003 the USA commenced a Carbon Sequestration Leadership Forum and encouraged Annex I and non-Annex I signatory countries to the United Nations Framework Convention on Climate Change to become members. This forum has been successful in furthering the link of climate governance with carbon capture and storage, and in technology deployment.³⁹

Growing international support has been seen for the development of CCUS, but advancements have only been seen for the CCS aspect, and not much for CCU, except for enhanced oil recovery (EOR). For example, the Intergovernmental Panel on Climate Change, the G8, and the International Energy Agency have been involved in the Carbon Sequestration Leadership Forum and the Global Carbon Capture and Storage Institute.⁴⁰ As a consequence of international support and governance innovation, the CCS element of CCUS has been incentivized strategically under international climate law.⁴¹ As a result, we can acknowledge the development for CCS and its activities, under which demonstrations and dissemination of knowledge concerning the matter have proliferated. However, nowhere do we see an initiative being taken internationally to independently recognize the ‘utilization’ aspect of CCUS, and no regulatory mechanisms are in place recognizing and abridging such a gap.

CCU advancement has faced a hold back due to the deployment process being risky and expensive.⁴² This is more so because it entails investing in capital-intensive

³⁸ Ibid.

³⁹ <https://fossil.energy.gov/archives/cslf/About-CSLF.html> accessed 1 November 2024.

⁴⁰ Jürgen-Friedrich Hake and Olga Shenk, ‘International Cooperation in Support of CCUS’, in Alexandre Gallo and others (eds), *Towards the International Standardization of Carbon Dioxide Capture, Transportation, Utilization and Storage (CCUS) Technologies: Current Challenges and Future Directions* (2021) *J Sustain Dev Law Policy* 12(2) 157–189 <https://dx.doi.org/10.4314/jsdlp.v12i2.2>.

⁴¹ Alexandre Gallo, Eduardo G. Pereira, Alberto Fossa, Hannah Hylton-Edwards, Thomas Muinzer, Edmilson Moutinho dos Santo, Clara Dybwad, & Cylon Liaw, ‘Towards the International Standardization of Carbon Dioxide Capture, Transportation, Utilization and Storage (CCUS) Technologies: Current Challenges and Future Directions’ (2021) *The Journal of Sustainable Development, Law and Policy* 12(2) 157–189.

⁴² Ibid.

technology on one hand, and dealing with the storage of dangerous waste on the other.⁴³ Further, advancement of CCU has also been affected by the tradeoff between the deployment of large-scale projects, and the preservation of portfolio of competing technologies at each developmental stage. Large scale projects have been seen to prefer the business model of EOR for CCS;⁴⁴ one of the largest projects in the world being currently in Brazil.⁴⁵ However, there is a need to prove the economic viability when variant carbon emitters are used. Further, there is a recognized need to search for alternative carbon uses and energy sources that are better adapted to carbon sources that are of a smaller source.

Bridging the gap in CCU advancement necessitates the development of a comprehensive regulatory framework to facilitate the utilization of CO₂. Such a framework should ensure safe and permanent storage, standardization of CCUS products, and the conduct of life cycle assessments. For this goal, it is essential to establish policies that incorporate financial incentives, carbon pricing mechanisms, and frameworks aimed at raising public awareness.

In this regard, the implementation of national and international legal and regulatory structures that promote transparency, establish clear liability, and govern long-term monitoring and utilization seems crucial. Additionally, technical oversight committees, that oversee each stage of the CCUS lifecycle, and ensure best practices in technology, environmental management, verification, and safety, could play a relevant role in addressing the disparities in CCS and CCU development thereby, fostering a more balanced approach to CCUS activities globally.

⁴³Ibid.

⁴⁴Ibid.

⁴⁵ The CCUS program developed by Petrobras in the pre-salt fields is the largest operational program in the world in terms of annual reinjection volume and is also the pioneer in ultra-deep waters. Petrobras has been increasing the volume of CO₂ reinjected into reservoirs each year. In 2022, it set a world record for CCUS, according to the Global CCS Institute, reaching a total of 10.6 million tons reinjected—equivalent to 5.8 billion cubic meters of CO₂, which represents about 25% of the total volume reinjected by the global industry; See CCUS: Captura e Armazenamento de Carbono (Petrobras, n.d.) <https://agencia.petrobras.com.br/w/ccus> accessed 29 October 2024.

5. DISPARITY BETWEEN ADVANCEMENTS IN CCS AND CCU: BRAZIL AS A CASE STUDY

Despite Brazil's prominent position in terms of CO₂ reinjection volumes under CCU projects,⁴⁶ the country still faces significant regulatory challenges in building a large-scale decarbonization industry. Although there is recent, albeit embryonic, legislation aimed at regulating CCS activities, Brazil currently lacks a regulated carbon trading market.

On May 19, 2022, Brazil issued the now-revoked Decree No. 11,075,⁴⁷ which, contrary to initial expectations, did not establish a regulated carbon market. Instead, it set procedures for developing Sectoral Climate Change Mitigation Plans, permitting commercial activities, transfers, transactions, and the retirement of certified emissions reduction credits. This decree defined a carbon credit as a financial, environmental, and transferable asset, representing the reduction or removal of one metric ton of carbon dioxide equivalent (CO₂e) recognized and issued in either voluntary or regulated markets. This initial definition marked a departure from previous classifications that considered carbon credits as either securities or proprietary rights.

With the expansion of the carbon market, a clear legal definition is essential to support financing mechanisms and provide legal certainty, especially if credits are considered fungible—an attribute that would enhance liquidity in the market. In a regulated carbon market, emission allowances are often best categorized as financial assets, particularly if a financial institution manages them. The revoked decree further included carbon stocks and methane credits as financial assets, which could facilitate tracking of methane emission reductions and support Brazil's commitments to mitigating this potent greenhouse gas.⁴⁸

However, the lack of a comprehensive regulatory framework significantly hampers the development of a large-scale decarbonization industry and the advancement of CCUS projects in Brazil. The continuing absence of well-defined rules for carbon credit generation, trading, and recognition introduces uncertainties that deter large-scale investment. CCUS projects, which depend on monetizing carbon credits to offset high operational costs, are especially impacted. In countries with regulated carbon markets, these projects benefit from frameworks that incentive emissions reductions and

⁴⁶ CCUS: Captura e Armazenamento de Carbono, *Ibid.*

⁴⁷ Brazil, Decree No 11.075 of 19 May 2022 <https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2022/decreto/D11075.htm> accessed 31 October 2024.

⁴⁸ International Chamber of Commerce Brazil, 'Relatório ICC Brasil 2022: Oportunidades para o Brasil em Mercados de Carbono' (October 2022) <https://www.iccbrasil.org/wp-content/uploads/2022/10/RELATORIO_ICCBBR_2022_final.pdf> accessed 31 October 2024.

enhance credit fungibility. Without a similar structure, Brazil's ability to scale decarbonization efforts across high-emission sectors remains limited.

Several legislative proposals are now under consideration in the National Congress to define a regulatory framework for Brazil's carbon market. Among these, Bill No. 2,148/2015⁴⁹, is seen as pivotal. This bill establishes the Brazilian System of Greenhouse Gas Emissions Trading (SBCE), based on the internationally recognized cap-and-trade system. This system sets a maximum emissions limit and allows for the trading of emission rights, referred to as Brazilian Emission Quotas (CBE) in the bill.

Under the proposed legislation, activities, sources, and facilities emitting over 25,000 tons of CO₂ equivalent per year will be subject to the emissions cap.⁵⁰ Those emitting over 10,000 tons per year will only be required to present an emissions monitoring plan to the SBCE management authority. These limits apply to all sectors of the economy, except for primary agricultural production. Additionally, the bill allows for the use of voluntary carbon market credits in the SBCE, provided certain requirements are met. A maximum limit on the use of these credits for compliance purposes will be established.

Also under this context, the National Policy on Climate Change (PNMC), enacted by Federal Law No. 12,187/2009⁵¹, aims to implement the National System for Greenhouse Gas Emissions Reduction (SINARE), a centralized registry for emissions, removals, reductions, and greenhouse gas (GHG) compensations.

In addition, the ANP approved, on April 25, 2024, the Report on the Implementation of the Regulatory Framework for Carbon Capture, Use and Storage⁵² through Resolution No. 256/2024⁵³. This resolution also established that, until the regulation of CCUS activities is implemented, pilot project regulations will be adopted for ongoing or upcoming projects. The CCUS Report explains that, given the attribution of regulatory competence to the ANP by recent legislation on the CCUS market, the

⁴⁹ Brazil, *Projeto de Lei No 2.148/2015* (Chamber of Deputies, 2015) <https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=1548579&fichaAmigavel=nao> accessed 1 November 2024.

⁵⁰ Ibid.

⁵¹ Brazil, *Federal Law No 12,187 of 29 December 2009* https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm accessed 31 October 2024.

⁵² *Relatório de Implementação do Marco Regulatório de Carbon Capture, Use and Storage – CCUS* (2024) https://www.gov.br/anp/pt-br/canais_atendimento/imprensa/relatoriocusstm24.04.09.pdf accessed 29 October 2024.

⁵³ *Resolução da Diretoria da Agência Nacional do Petróleo, Gás Natural e Biocombustíveis – ANP* (25 April 2024) Processo nº 48610.235448/2023-95, RD nº 256/2024, https://www.gov.br/anp/pt-br/canais_atendimento/imprensa/relatoriocusstm24.04.09.pdf accessed 29 October 2024.

agency proactively studied the topic to support the industry's growth. This approach aligns with recent legislative developments, such as Law No. 14.993 of October 8, 2024⁵⁴—originating from PL 528/2020⁵⁵—as well as ongoing bills like PL 1425/2022⁵⁶.

In this regard, Chapter VI of Brazil's new Law No. 14.993/2024 outlines regulations governing CCS within the industry.⁵⁷ Key provisions include:

- **Authorization by the ANP:** CCS activities, including pipeline transport and geological storage, require authorization from Brazil's National Agency of Petroleum, Natural Gas and Biofuels (ANP). Only companies or consortia with headquarters in Brazil are eligible, and operations are at the applicant's risk. The authorization period is set at 30 years, renewable under compliance with established terms, though subject to adjustment by the government.
- **Exemptions and Conflict Resolution:** CO₂ injection for enhanced hydrocarbon recovery under current contracts is exempt. In case of conflict between CCS activities and hydrocarbon or mining operations, priority will be determined by the Minister of Mines and Energy.
- **Operational and Technical Standards:** CCS activities must adhere to economic and environmental efficiency, apply region-specific best practices, and utilize integrated infrastructure and geological data for effective resource management.
- **ANP Oversight and Data Access:** The ANP will regulate CCS operations and may revoke authorization for non-compliance. Operators will have access to public geological data for potential storage site evaluation.
- **Operator Responsibilities:** Operators must maintain safe storage, monitor for leaks, keep accurate records, and facilitate ANP audits. They are also required to maintain CO₂ inventory and performance records for potential carbon credit certification under international or national programs.

⁵⁴ Brazil, *Lei No 14.993, de 8 de Outubro de 2024* <https://legis.senado.leg.br/norma/39738545/publicacao/39740200> accessed 30 October 2024.

⁵⁵ *Proposição nº 528/2020* (n.d.) <https://www25.senado.leg.br/web/atividade/materias/-/materia/162696> accessed 29 October 2024.

⁵⁶ *Proposição nº 1425/2022* (n.d.) <https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=2388818> accessed 29 October 2024.

⁵⁷ *Lei No 14.993, de 8 de Outubro de 2024* (n 54).

It is notable that EOR remains a point of controversy in this discussion. Although the technique, which involves both the use and storage of carbon, has been adopted in Brazil since 2008, it was expressly excluded from regulation under Law No. 14.993/2024. The ANP argues that EOR is currently implicitly regulated through exploration and production contracts, existing laws, and established good oil practices.

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6. LESSONS LEARNED

In order to cater to the complex issues that CCUS development poses, sophisticated legal and regulatory schemes have been put in place within countries and regions.⁵⁹ It has been recognized through the experience with CCS and its regulatory development that an effective legal regime should be in place that holds both a national and international character.⁶⁰ Such a framework should cover matters of long-term liability for storage, regulation of transport, treatment of carbon under emission trading regimes, property ownership, and public engagement.⁶¹ Each stage of CO₂ utilization thus requires regulatory recognition. Further, the issues concerning CCS and CCU may converge, which need to be regulatory accounted for. There should be a balance between these regulatory regimes, to prevent any potential prioritization at the expense of the other.⁶² A strong degree of harmonization is seen to be necessary for the development of CCUS and its legal regimes,⁶³ which also includes harmonization in the usage of CO₂. Standardization can be especially important in providing reliability when the CCUS is being deployed in the global context, permeating multiple jurisdictions.

⁵⁸ *Relatório de Implementação do Marco Regulatório de Carbon Capture, Use and Storage – CCUS* (n 4).

⁵⁹ See further Dirk Uwer and Daniel Zimmer, *Carbon Capture and Storage: The Legal Landscape of Climate Change Mitigation Technology* (Globe Law and Business Ltd, 2020).

⁶⁰ Alexandre Gallo, Eduardo G. Pereira, Alberto Fossa, Hannah Hylton-Edwards, Thomas Muinzer, Edmilson Moutinho dos Santo, Clara Dybwad, & Cylon Liaw, 'Towards the International Standardization of Carbon Dioxide Capture, Transportation, Utilization and Storage (CCUS) Technologies: Current Challenges and Future Directions' (2021) *The Journal of Sustainable Development, Law and Policy* 12(2) 157-189.

⁶¹ Ian Havercroft, Richard Macrory and Richard Stewart (eds), *Carbon Capture and Storage: Emerging Legal and Regulatory Issues* (Bloomsbury, 2018).

⁶² *Ibid.*

⁶³ Hao Zhang, 'Regulations for carbon capture, utilization and storage: Comparative analysis of development in Europe, China and the Middle East' (2021) 173 *Resources, Conservation and Recycling* 105722.

The status of CCUS has been such that it is currently almost exclusive to the global north due to its high upfront cost of capital. The market is predominantly dominated by the US, followed by Europe, Canada, then China and emerging wealthy nations in the Middle East region. Developed countries have exhibited a strong economic ability to incentivize the establishment of CCUS industries in their territories. Lessons can be learnt from the activities of the US and Canada, who have been attracting investors through their tax incentives.⁶⁴ Specifically, US has applied its 45Q tax-incentive credits⁶⁵, which focuses on public funding and R&D, addressing environmental justice as well through its Justice 40 program. Canada has enforced tax credits for CCUS schemes coupled with stringent carbon pricing regulations. CCUS may also be further incentivized through its system that offsets carbon credits through its Greenhouse Gas Offset Credit system.⁶⁶

Carbon taxation holds potential to significantly contribute to the Paris Agreement goals⁶⁷ due to its role of acting as a tool providing economic incentive to reduce greenhouse gas emissions, as has been in the case of CCS. Further, government subsidy schemes are another important tool that incentivize investors, where the government compensates them in the instance that the returns are lower than anticipated. Example is posed of the Dutch government, where this scheme was applied targeting technologies lowering CO₂ emissions while transitioning to sustainable energy.⁶⁸ Such an approach could be applied in the hope of developing CCU as well.

Best practices should be reviewed while formulating legal frameworks concerning CCU. This acts as a useful starting point for the process. Australia and Canada have had legal and regulatory CCUS frameworks in place for more than a decade (including at sub-national levels). Meanwhile, other countries are now starting the process of developing legal and regulatory frameworks for CCUS to meet climate goals.

⁶⁴ Office of the Parliamentary Budget Officer, *Investment Tax Credit for Carbon Capture, Utilization and Storage* <https://www.pbo-dpb.ca/en/publications/LEG-2324-022-S--investment-tax-credit-carbon-capture-utilization-storage--credit-impot-investisment-captage-utilisation-stockage-carbone>.

⁶⁵ Congressional Research Service, 'The U.S. Economy: A Historical Perspective on Economic Trends' (2023) <https://crsreports.congress.gov/product/pdf/IF/IF11455> accessed 29 October 2024.

⁶⁶ Government of Canada, 'Federal Greenhouse Gas Offset System' (2024) <https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system/federal-greenhouse-gas-offset-system.html> accessed 29 October 2024.

⁶⁷ Paris Agreement, Article 4(2).

⁶⁸ Dutch Ministry of Economic Affairs and Climate Policy, *SDE++ 2023: Stimulation of Sustainable Energy Production and Climate Transition* <https://english.rvo.nl/sites/default/files/2023-09/BrochureSDE2023English.pdf>.

Implementation of the world's first national (offshore) CO₂ storage laws in Australia took over five years, from 2003 to 2008.⁶⁹ However, the experience gained from this early work can inform the development of future frameworks, which could potentially be formulated within the duration shorter than the one that Australia had invested into.

The US, through the application of ISO 27916 has provided tax credit on a per-tonne basis long-term geologic storage, on the condition that emission reductions are clearly demonstrated. This helps secure storage as well as incentivize the reduction of emissions.

From another perspective, Brazil's experience highlights the critical importance of a robust regulatory framework for the successful implementation of CCUS projects. Despite Brazil's significant CO₂ reinjection volumes, the absence of a regulated carbon trading market and comprehensive legislation has hindered the development of a large-scale decarbonization industry. The now-revoked Decree No. 11,075, which failed to establish a regulated carbon market, underscores the need for clear legal definitions and structured financial mechanisms to support carbon credit trading. Without these, uncertainties persist, deterring large-scale investments necessary for CCUS projects, which rely heavily on the monetization of carbon credits to offset high operational costs.

The ongoing legislative efforts, such as Bill No. 2,148/2015, which proposes the SBCE, are crucial steps towards addressing these regulatory gaps. This bill aims to create a cap-and-trade system, setting emission limits and allowing the trading of emission rights, which could provide the much-needed legal certainty and financial incentives for emissions reductions. Additionally, the recent ANP resolution and the new Law No. 14.993/2024, which outline regulations for CCS activities, reflect a proactive approach to building a regulatory framework. However, the exclusion of EOR from these regulations indicates ongoing challenges in aligning industry practices with regulatory standards. Overall, Brazil's case illustrates that comprehensive and clear regulations are essential for fostering investment and scaling up decarbonization efforts.

7. RECOMMENDATIONS AND CONCLUSION

There is a clear gap in the regulation and development of the utilization part of CCUS, consequently affecting its advancement. Its exception however is the process of enhanced oil recovery. But beyond EOR, there is underdevelopment of regulations and frameworks for carbon utilization. The development of CCUS, and CCU, is dependent

⁶⁹ International Energy Agency, *Legal and Regulatory Frameworks for CCUS: An IEA CCUS Handbook* <https://iea.blob.core.windows.net/assets/bda8c2b2-2b9c-4010-ab56-b941dc8d0635/LegalandRegulatoryFrameworksforCCUS-AnIEACCUSHandbook.pdf>.

on successful regulations that provide for safe and permanent storage of utilized carbon, standardization of carbon products, and life cycle assessments. A concerted effort is hence required to bridge this regulatory gap.

Regulations concerning utilization have struggled to be in place mainly due to the issue circulating around CCUS itself, which is that it is high in cost, there is a lack of infrastructure in place to cater to CCUS, and public perception, or lack thereof concerning CCUS. To counter such hindrances, there should be frameworks in place that provide for policy interventions, which cover matters of financial incentives, carbon pricing, and regulatory frameworks providing for public awareness.

An appropriate national as well as international legal and regulatory framework is needed that facilitates the utilization of CO₂. Such a framework should be aided through transparency and should establish clear liability as well as govern the monitoring of long-term storage and utilization. Implementing technical oversight committees throughout the CCUS lifecycle, from capture to storage, and utilization, is also recommended. Such committees ensure that there are qualified personnels overseeing each stage, and that best practices are implemented in the areas of technology, environmental management, verification, and safety. A proper regulatory framework can also help bridge the disparity that has been faced internationally in regard to CCU development, where the global north has partaken in a disproportionate abundance of CCUS activities.