International Journal of Emerging Research in Engineering, Science, and Management
Vol. 3, Issue 3, pp.46-50, Jul-Sep 2024.
www.ijeresm.com eISSN – 2583-4894

Carbon Capture and Storage – Legal and Policy Considerations for Sustainable Energy Solutions

Mohd Aqib Aslam

Research Scholar, Department of Law, University of Jammu, Jammu Tawi (J&K), 180006, India. aqibaslam566@gmail.com

Abstract: Carbon capture and storage (CCS) has become a vital technological advancement in the fight against climate change by lowering greenhouse gas emissions from energy generation and industrial operations. However, the development and application of CCS technologies confront formidable legal and policy obstacles despite their potential to help achieve global carbon reduction goals. This study examines the legislative and policy tools required to support the implementation of CCS as a sustainable energy choice. To solve these issues, it evaluates national, regional, and international legal methods and the regulatory gaps that prevent CCS projects from being widely implemented. The analysis focuses on identifying the factors that hinder and facilitate the deployment of CCS, including environmental regulations, intellectual property rights, liability concerns, and public participation. The research also examines how current international climate agreements, like the Paris Agreement, impact CCS's regulatory environment. This paper identifies optimal methods for establishing a favorable legal environment by evaluating case studies from nations with advanced CCS efforts. Lastly, suggestions are made for coordinating legislative and regulatory frameworks so that CCS can significantly contribute to realizing sustainable energy transitions.

Keywords: Carbon Capture and Storage, Environmental Law, Climate Policy, Sustainable Energy, Regulatory Frameworks.

1 INTRODUCTION

Growing greenhouse gas (GHG) emissions make climate change one of the twenty-first century's most urgent challenges. Carbon dioxide (CO_2) emitted by the combustion of fossil fuels for energy and industrial activities is one of the main contributors to GHGs. CCS is widely acknowledged as a crucial technique for reducing greenhouse gas emissions from high-emitting industries, including power generation, steel, and cement production, as nations shift towards a more sustainable future [1]. To keep CO_2 from entering the atmosphere, CCS entails removing CO_2 from the emission source, moving it, and storing it in geological formations like depleted oil fields. Despite significant technological developments, policy and legal issues still prevent the device from being widely used. To overcome these obstacles, this article thoroughly examines the laws and regulations necessary to implement CCS effectively.

2 THE SCIENCE AND TECHNOLOGY OF CARBON CAPTURE AND STORAGE

2.1 Carbon Capture

Post-combustion capture is the most developed and frequently used method. It entails removing CO2 from the flue gases left behind from burning fossil fuels. This approach has several advantages because it can be retrofitted to existing power facilities. Amines are frequently employed in gas stream CO_2 absorption processes. Before combustion, pre-combustion capture entails gasifying fossil fuels to turn them into a hydrogen and CO_2 combination. Power is generated using hydrogen in this gas mixture while the CO_2 is extracted. Though less suited for retrofitting existing plants, pre-combustion capture is frequently more effective. Oxyfuel combustion is a technique that burns the fuel in pure oxygen rather than air, resulting in a flue gas primarily divided into readily separable CO_2 and water vapor. The creation of oxygen is necessary, which makes the process expensive even if oxy-fuel combustion has a great potential for effective CO_2 extraction [2].

2.2 Transportation of CO_2

An essential part of the CCS process is the transportation of collected CO_2. The most popular approach is to use pipelines, and there is already a sizable network in place in countries like the United States for moving CO_2 to enhanced oil recovery (EOR) locations. New pipeline construction crosses international borders and presents several legal and regulatory challenges concerning environmental effects, land use rights, and safety regulations. Longer-distance CO_2 transmission via ships is also possible; however, this approach is less established. Strict guidelines are needed for handling, storing, and safely shipping CO_2. International maritime regulations must change to address the dangers of large-scale CO_2 trafficking [3].

2.3 Storage

Upon transportation, CO_2 is injected into underground geological formations for permanent storage. Different geological formation kinds are considered for storage: Depleted oil and gas reservoirs: geologically well-understood and have already demonstrated their capacity to hold gases, these locations are perfect for storing CO_2.

More poorly known than oil and gas reserves, saline aquifers are porous rock formations packed with saltwater and large storage capacity [4]. Although they are typically viewed as less advantageous than other choices, unmineable coal seams can also trap CO_2. Keeping CO_2 in storage for an extended period is very difficult. To make sure that CO_2 does not leak into the atmosphere, regulatory control is required to monitor sites for decades or even centuries. One of the main things preventing CCS from spreading further is the lack of long-term liability frameworks for leakage.

3 CURRENT STATUS OF MILLET PRODUCTION IN CHHATTISGARH

3.1 International Legal Context

An important international agreement establishing targets for reducing carbon emissions is the Paris Agreement, a part of the United Nations Framework Convention on Climate Change (UNFCCC). It is acknowledged that CCS is one of the technologies that can help reach the goals established by this agreement. However, local countries are responsible for creating laws as the Paris Agreement does not provide precise legislative standards for implementing CCS.

3.2 Regional Legal Perspectives

Directive 2009/31/EC provides a legal basis for CCS on the geological storage of CO_2 in the European Union (EU) [5]. The directive lays out guidelines for the safe and long-term storage of CO_2 in EU member states, including post-closure duties, site selection criteria, and monitoring procedures. Under the framework of already-existing environmental regulations like the Safe Drinking Water Act and the Clean Air Act, some countries, like the United States, have also established legal criteria for CCS.

3.3 National CCS Laws

Nations like Australia and Norway have established strong foundations for CCS legislation to support ongoing initiatives. Among the most successful CCS deployments worldwide is still Norway's Sleipner project, which got underway in the middle of the 1990s. The legal obligations of CO_2 storage are outlined in Norway's Petroleum Act, which was modified to control CCS. An offshore CCS concept and regulations for CO_2 injection and storage operations are provided under the Offshore Petroleum and Greenhouse Gas Storage Act (OPGGSA) of Australia [6].

4 REGULATORY CHALLENGES AND LIABILITY ISSUES

4.1 Environmental Law and Permitting

Sites that use carbon capture and storage are subject to numerous environmental requirements. Although national permitting procedures differ, most involve thorough ecological impact evaluations, especially during the storage stage. These analyses investigate the possible dangers of groundwater pollution, the effects of CO_2 leakage, and the effects on nearby ecosystems. The EU Directive 2009/31/EC governs CCS permitting in places like the European Union [5]. The directive lists specifications for reporting, monitoring, and corrective action in case of storage site leaks. However, legislative discrepancies between countries and regions can complicate the approval process, especially for transboundary CCS projects [7].

4.2 Liability for CO_2 Leakage

Regarding long-term CO_2 storage, accountability for leaks or environmental harm is one of the main concerns. Governments and business participants are unsure who will be responsible if CO_2 escapes from storage facilities for decades. Several nations have created financial assurance systems to insure against future hazards, while others have implemented long-term liability frameworks. Operators are responsible for the stored CO_2 for a certain amount of time after the station closes, following the EU CCS Directive. After that time, the operator must show that there is no material risk of CO_2 leakage from the stored gas before the state assumes responsibility. Because it necessitates precise monitoring technology and long-term planning, this transfer of guilt is still a difficult topic.

4.3 International Law and Cross-Border CCS Projects

Extra regulatory obstacles exist for cross-border CCS projects, especially when moving and storing CO_2 across national borders. Because there is a lack of defined international law on the subject, there are questions regarding jurisdiction, liability, and environmental protection. For example, the export of CO_2 for storage in sub-seabed formations was formerly forbidden by the London Protocol, an international agreement designed to avoid marine contamination. Though signatories haven't widely accepted it, an adjustment was proposed in 2009 to permit cross-border transfer of CO_2 for geological storage.

5 POLICY CONSIDERATIONS FOR CCS DEPLOYMENT

5.1 Government Incentives and Subsidies

Governments must give the private sector financial incentives to advance CCS. Examples are subsidies, tax breaks, and carbon pricing tools like emissions trading systems (ETS). For example, businesses that absorb and store CO_2 can benefit financially from the US 45Q tax credit.

5.2 Carbon Pricing Mechanisms

Carbon pricing is essential to encourage businesses to implement CCS. Governments can make CCS financially feasible by placing a price on CO_2 emissions through a carbon tax or cap-and-trade schemes. However, the level of prices and the stability of the regulatory framework affect how effective carbon pricing is.

5.3 Public-Private Partnerships

Public-private partnerships (PPPs) are a common feature of successful CCS projects. Through these collaborations, governments may benefit from the creativity and experience of the private sector while sharing the financial risks involved in large-scale CCS initiatives. The Petra Nova project in Texas, USA, is one noteworthy example of how industry and government cooperation has been crucial to its success.

6 CASE STUDIES OF CCS IMPLEMENTATION

Case Study 1: The U.S. Clean Air Act and CCS Projects

The Clean Air Act in the US offers a legislative foundation for controlling CO_2 emissions from power plants. The Environmental Protection Agency (EPA) is required by Section 111 of the Act to establish performance guidelines for both new and existing power facilities [8]. This clause allowed CCS to be incorporated into US environmental policy, especially with the Clean Power Plan (CPP), which promoted using CCS to lower CO_2 emissions from the electricity industry. The Biden administration has reenergized climate policy, backing CCS as part of larger measures to decarbonize the energy sector, despite the Trump administration’s rollback of the CPP. Through its Carbon Capture Program, the U.S. Department of Energy (DOE) has also aided in CCS's research and development.

Case Study 2: Norway’s Sleipner Project

More than 20 million tons of CO_2 have been stored by the historic Sleipner project in Norway, which has operated since 1996. The Sleipner field produces natural gas, which is used to extract CO_2 and then store it in a saline aquifer beneath the North Sea. The Petroleum Act of Norway, which was modified to incorporate guidelines for the safe storage of CO_2, governs the project [9]. Norway has strict reporting and monitoring guidelines for CCS, guaranteeing that the stored CO_2 is kept safely confined. The Norwegian Petroleum Directorate oversees the project and must submit an annual report on storage integrity. Because of Sleipner’s performance, Norway is now a global leader in CCS, and other nations wishing to implement CCS can refer to its legislative framework as a model.

Case Study 3: Australia’s CCS Initiatives

With the OPGGSA, Australia has taken the lead in creating a legislative and regulatory framework for CCS. In addition to laying forth specifications for long-term liability, licensing, and monitoring, the OPGGSA controls the injection and storage of greenhouse gases in offshore geological formations. Large-scale CCS projects have also been carried out in Australia, notably the world's largest CCS project, the Gorgon Project in Western Australia. The Gorgon Project injects CO_2 into a deep geological formation beneath Barrow Island by capturing it during natural gas processing. An important component of Australia’s emissions reduction plan, the project is anticipated to store up to 4 million tons of CO_2 yearly [10]. In Australia, there is strong public hostility to CCS despite its promise. Environmental groups are especially concerned about the possibility of CO_2 leakage and the possibility that CCS may increase the amount of fossil fuels used. A clear regulatory framework and public participation will be essential to addressing these issues and ensuring the continued viability of CCS in Australia.

7 PUBLIC ENGAGEMENT AND SOCIAL ACCEPTANCE

7.1 Public Perception of CCS

Project success or failure can be attributed to several factors, including the general acceptance of CCS. According to studies, there is generally little public knowledge of CCS, and misunderstandings about the technology—such as worries about CO_2 leakage or environmental damage—can fuel opposition. As a result, getting support for CCS efforts requires active public participation. To give local communities accurate information about the advantages and hazards of CCS, governments and project developers must get involved with them early in the development phase. Building confidence and ensuring that stakeholders are informed and involved in decision-making can be achieved through public consultations, community gatherings, and educational initiatives [11]-[13].

7.2 Addressing Public Concerns

The security of CO_2 storage facilities is one of the main worries of the general population. Strict monitoring and verification procedures should be incorporated into legislative frameworks to alleviate these worries and guarantee that CO_2 is stored securely. Clear criteria about culpability and compensation in the event of a leak can also assist in addressing concerns and boosting trust in CCS technologies.

CCS initiatives also need to be viewed in the larger framework of mitigating climate change. The public opinion of CCS can be changed from a band-aid solution to one of the essential components of the worldwide switch to sustainable energy by emphasizing its role in accomplishing national and international climate goals.

8 RECOMMENDATIONS FOR HARMONIZING LEGAL AND POLICY FRAMEWORKS

Harmonizing legal frameworks and working together to develop policies are two ways nations can encourage using CCS. Sharing best practices, technical know-how, and regulatory strategies requires international cooperation. In addition to coordinating national policies with global climate goals, this could involve the creation of international treaties or standards unique to CCS. Governments should also consider creating long-term liability funds to mitigate the risks related to CO2 storage and clarify accountability in the case of a leak. Public involvement must also be formalized within legal parameters to guarantee that interested parties are informed and participate in developing CCS projects.

9 CONCLUSIONS

Carbon capture and storage provide a major chance to lower CO2 emissions and support global climate goals. However, overcoming significant legal, regulatory, and societal obstacles is necessary for its implementation. As case studies and legal framework analysis have shown, a concerted effort is required to create precise and uniform legislation that supports CCS while guaranteeing long-term safety and environmental preservation. Governments must keep sponsoring CCS with financial incentives and regulatory support, including long-term liability and environmental risk management measures. Prioritizing public participation is also necessary to foster confidence and ensure that CCS initiatives are accepted by society. The key to guaranteeing that CCS becomes a fundamental part of sustainable energy solutions will be the harmonization of legal and policy frameworks, both domestically and internationally.

FUNDING INFORMATION

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ETHICS STATEMENT

This study did not involve human or animal subjects and, therefore, did not require ethical approval.

STATEMENT OF CONFLICT OF INTERESTS

The authors declare no conflicts of interest related to this study.

LICENSING

REFERENCES

[1] J. Gale and J. Davison, “Transmission of CO2—safety and economic considerations,” *Energy*, vol. 29, no. 9–10, pp. 1319–1328, May 2004, doi: 10.1016/j.energy.2004.03.090.
[2] “Carbon dioxide Capture and Storage — IPCC,” *IPCC*. https://www.ipcc.ch/report/carbon-dioxide-capture-and-storage/
[3] Haszeldine, R. S. "Carbon Capture and Storage: How Green Can Black Be?" *Science*, 2009, https://doi.org/1172246. Accessed 27 Sept. 2024.
[4] S. Bachu, “Sequestration of CO_2 in geological media: criteria and approach for site selection in response to climate change,” *Energy Conversion and Management*, vol. 41, no. 9, pp. 953–970, Jun. 2000, doi: 10.1016/s0196-8904(99)00149-1.
[5] European Commission, “Directive 2009/31/EC on the geological storage of carbon dioxide,” *Official Journal of the European Union*, L 140, pp. 114-135, Jun. 2009.
[6] J. Gibbins and H. Chalmers, “Carbon capture and storage,” *Energy Policy*, vol. 36, no. 12, pp. 4317–4322, Dec. 2008, doi: 10.1016/j.enpol.2008.09.058.
[7] “AR4 Climate Change 2007: Mitigation of Climate Change — IPCC,” *IPCC*. https://www.ipcc.ch/report/ar4/wg3/
[8] “Adoption and Submittal of State Plans for Designated Facilities: Implementing Regulations Under Clean Air Act Section 111(d),” *Federal Register*, Nov. 17, 2023. https://www.federalregister.gov/documents/2023/11/17/2023-25269/adoption-and-submittal-of-state-plans-for-designated-facilities-implementing-regulations-under-clean
[9] “The Petroleum Act and the licensing system - Norwegianpetroleum.no,” *Norwegianpetroleum.no*, May 23, 2024. https://www.norskpetroleum.no/en/framework/the-petroleum-act-and-the-licensing-system/
[10] G. Australia, “Carbon capture and storage,” *Geoscience Australia*, Jul. 23, 2024. https://www.ga.gov.au/aecr2024/carbon-capture-and-storage

[11] Witte Katja, "Social Acceptance of Carbon Capture and Storage (CCS) from Industrial Applications," *Sustainability*, vol. 13, no. 21: 12278, 2021, doi: 10.3390/su132112278.
[12] P. Tcvetkov, A. Cherepovitsyn, and S. Fedoseev, "Public perception of carbon capture and storage: A state-of-the-art overview," *Heliyon*, vol. 5, no. 12, p. e02845, Dec. 2019, doi: 10.1016/j.heliyon.2019.e02845.
[13] S. Karytsas, O. Polyzou, T. I. Oikonomou, and C. Karytsas, "A transnational study on the determinants of social acceptance of carbon capture, transport, and storage (CCS)," *IOP Conference Series Earth and Environmental Science*, vol. 1196, no. 1, p. 012092, Jun. 2023, doi: 10.1088/1755-1315/1196/1/012092.