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CCS: The Brazilian Perspective

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Abstract

The objective of this article is to discuss Brazil's possibilities for implementing out CCS projects, in the medium term. Several aspects are analyzed. They indicate that Brazil provides excellent opportunities for the implementation of CCS projects with potential to store from 297 to 2087 Giga tons of CO_2 (Kearns, J. et al. 2017). This article analyzes technical, political, legal, geographical, geological and economical aspects that may influence CCS implementation in Brazil. The aspects considered are technology, legislation, industrial sources and storage sites as well as the proximity between them, and funding possibilities. This comprehensive analysis permits us to point out the main strengths and weaknesses of the large-scale implementation of CCS in Brazil.

Introduction

Brazil has excellent possibilities for implementing CCS in the medium term. In this article, we present the main driving forces for the rapid implementation of CCS projects, and two aspects that may delay project applications. Regarding technology, Brazil already hosts what is arguably the largest (in terms of injected volumes) CCUS offshore project in the world, currently in operation in the oil fields producing from the Pre-Salt formations in the Santos basin. This attests to the Brazilian technological capacity already available for new projects in the near future. Furthermore, the Brazilian government has taken important steps in passing legislation towards regulating the carbon market and associated CCS activities, an effort that brings tangible progress for its sustainability policy. This article highlights the types of projects that are most likely to be implemented, thanks to the proximity between sources and possible storage reservoirs. The most worrying aspects in this scenario are the virtual impossibility of substantial government financing and, secondly, the slow and gradual nature of the legal implementations underway in Brazil.

Technology Availability and Current Projects

Technology maturity is a positive aspect of the Brazilian CCS scenario. The national oil company, Petrobras, already injects carbon dioxide for CCUS in the Pre-Salt oil province, about 300 kilometers from the coast, in the supergiant fields Tupi, Sapinhoá and Búzios. CO_2 is separated from the natural gas associated with the produced oil and reinjected into the reservoir, in a WAG process. The purified natural gas is transported to the coast in pipelines. In Mero field, all natural associated gas is reinjected, due to its high carbon dioxide content (Nunes, J.P.P et al., 2024).

Petrobras announced that a total of 13 MM tons of CO_2 were injected into these fields in 2023, totaling 53.8 MM tons of CO_2 since the beginning of the injection period (2010) (Petrobras, 2024). The expected cumulative value in 2025 is 80 MM tons of CO_2 . These are very impressive numbers, especially considering the distance of the fields from the coast, and the water depth of 2,000 to 2,500 m. From an operational point of view, this injection is identical to geological sequestration with CO_2 from industrial sources. If continuous injection of CO_2 is desired after the fields are depleted, some modifications to the original project are necessary, but their implementation is feasible. These include ensuring the geomechanics integrity of storage reservoirs and the integrity of subsea wells and facilities, as well as monitoring plume formation and detecting leaks, assuring the perennity of CO_2 sequestration. This technological capacity, as is usually the case in the oil industry, is not concentrated solely in the hands of Petrobras, but is an achievement of the technological ecosystem comprised not only of the operator, but also of service companies, equipment suppliers, and R&D institutions. This technological community should facilitate the expansion of CCS projects in Brazil.

Other Ongoing Initiatives

In 2023, Petrobras has announced the planning of a CCS pilot project in the state of Rio de Janeiro. The project will capture CO_2 at a gas treatment plant owned by Petrobras, with injection scheduled to begin in 2027. 100,000 tons of CO_2 /year will be injected into the São Tomé formation, an offshore saline aquifer near the coast. Petrobras will apply all available advanced technologies to the construction of the pilot, including compositional and chemical flow simulation, well and gas pipeline materials integrity design and management, geomechanics simulation, 4 to 5 monitoring wells, and possibly 4D seismic to monitor the CO_2 plume (Pinto, I.A. et al., 2024). This will be a school project to acquire full knowledge of the CCS process.

Petrobras is also considering the construction of three carbon hubs in coastal areas with intense industrial activities (Ziglio, C.M., 2024). The idea would be to capture CO_2 from various industrial sources and transport it, through a network of pipelines, to deep offshore saline reservoirs close to the coast. Alternatively, it is conjectured that the CO_2 could be injected into depleted reservoirs in the oil fields in the Campos and Santos Basins, but the distance from the coast, respectively 100 and 300 km, would certainly increase costs and make logistics more difficult. OGCI (the Oil and Gas Climate Initiative), a joint initiative conducted by 12 of the most important oil operators, announced that Petrobras would consider an offshore hub in the Rio de Janeiro state, after the pilot development (OGCI, 2025). OGCI included this hub as its 12th carbon hub under its sponsorship.

The last noteworthy initiative was the carbon capture and sequestration project promoted by FS Bioenergy; a company dedicated to the production of ethanol from corn. The project is located in the state of Mato Grosso, in the interior of Brazil (FS Bioenergy, 2025). Although details of the project are not available on the FS Bioenergy website, it can be classified as a BECCS (Bioenergy with CCS) project. The storage reservoir chosen was a saline aquifer located 8 km from the ethanol production plant. A well

was drilled for the injection purpose. In a presentation at the 2024 SPE-AAPG-SEG CCUS Symposium, the company revealed operational difficulties possibly linked to injectivity problems (da Silva, A.C. et al., 2024).

Such ongoing initiatives echo a broader global trend where carbon hubs consolidate CO_2 storage activities in a centralized location. Brazil's approach, like other international efforts, seeks to harness economies of scale and create synergies between multiple industrial sources. Moreover, Bioenergy with CCS (BECCS) projects are becoming a focal point worldwide because they can achieve negative emissions by capturing more carbon than is released (IEA World Energy Outlook, 2023).

Legislation

The absence or existence of problems in the regulatory framework has been cited as one of the reasons for the slow progress of CCS activities in many countries. In this sense, the Brazilian federal government, actively engaged in the sustainability agenda, has promised over the last 2 years to approve relevant legislation before COP30, the climate UN conference to be held in 2025 in the city of Belém, Brazil (Câmara dos Deputados, 2023). In late 2024, the government approved two acts that could contribute decisively to ensuring that CCS activities take off in the country.

The first important piece of legislation is the Act 15042/2024, which regulates the Brazilian carbon market. This act enables the emergence of a regulated carbon market (ETS) by creating a Brazilian Greenhouse Gas Emissions Trading System (SBCE) that establishes a maximum ("cap and trade") of emissions for industrial activities, exempting agricultural, fertilizers and waste treatment activities. The carbon market will be regulated by the Comissão de Valores Mobiliários (Brazilian Securities and Exchange Commission). The implementation of the regulated market will be gradual, and its full implementation is expected to take from three to six years (Câmara dos Deputados, 2024-1).

The second important piece of legislation is the Act 14.993/2024. This act, among other points, addresses CCS activities in Brazil. The act determines that the ANP (National Petroleum Agency) will issue regulations regarding the activities of capturing, transporting, and storing CO_2 . ANP may also grant concessions for these activities for a period of 30 years, renewable for the same period. The act defines concessionaires obligations regarding safety, monitoring, contingency planning, maintenance, and obtaining carbon credits in a very generic way, transferring to the ANP the detailing of all regulations, procedures and technical standards to be followed by concessionaires. (Câmara dos Deputados, 2024-2).

As it can be seen, both acts unlock CCS activities, although they do so slowly and gradually. In the case of the the Act 14.993/2024, it will depend on the promptness and technical qualification of ANP, which, although held in high regard by the oil industry community in Brazil by its efficiency, will need some time to produce all the pertinent accessory legislation.

Sources and storage reservoirs

Brazil's industrial landscape presents a wide range of CO_2 sources, including oil and gas production facilities, petrochemical plants, cement and steel plants, and ethanol plants. Along the coastal states, where the largest sources of industrial and energy emissions are concentrated, many of these emission sources are situated near potential geological storage sites, which include offshore saline aquifers and depleted reservoirs in the Campos and Santos Basins. In the interior states, especially in the center and southeast of the country, onshore saline aquifers also present viable options if injectivity and monitoring concerns are adequately addressed.

The Brazilian Atlas of CO_2 Capture and Geological Storage (Ketzer, J.M.M. et al., 2014) provides a series of maps, two of which were selected and are shown in Figure 1, that help to visually understand the most feasible strategy for implementing CCS in Brazil. The most concrete possibilities are linked to (1) Carbon hubs along the southeast coast, capturing CO_2 from various industrial sources and injecting it into offshore saline aquifers. This strategy inspired Petrobras' proposal for three hubs. (2) Point capture next to ethanol plants or hubs capturing from several ethanol plants, in the center and southeast of the country, in processes classified as BECCS. FS Bioenergy pioneered this solution. (3) Hub from capture from industrial sources in the State of Bahia, in the Northeast of the country, using depleted oil reservoirs in the Recôncavo Basin. The storage phase may be preceded by a CCUS phase (capture and injection in EOR projects) in these depleted fields.

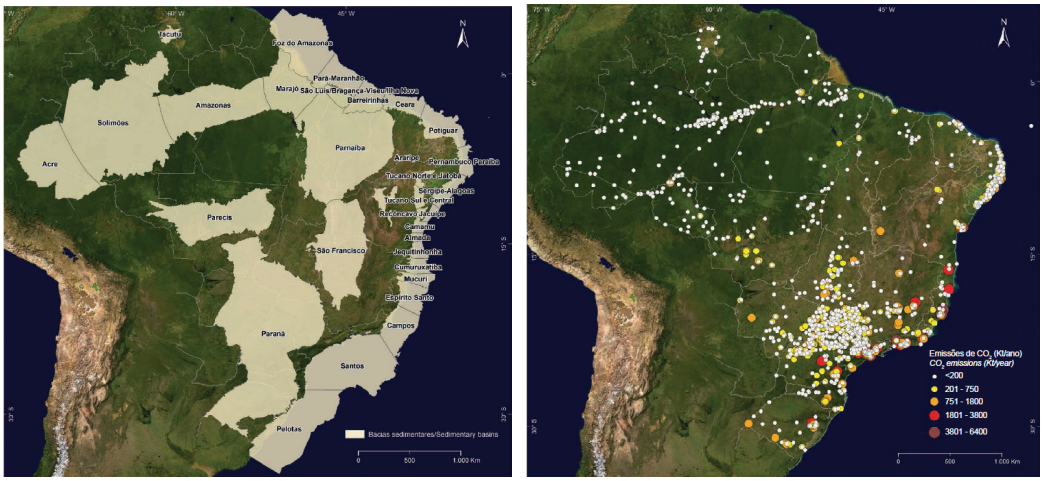

Figure 1. Brazil maps with sedimentary basins and emitting sources (Ketzer, J.M.M. et al., 2014)

Project Financing

Financing remains a significant challenge for CCS projects in Brazil. While the government has shown support through legislation, direct financial support is limited due to budgetary constraints. According to several financial analysts, the gross government debt is projected to reach 82.00% of GDP in 2025, and the primary balance is expected to be negative, with a deficit of approximately R$ 87.265 billion in 2025 (CNN Brasil, 2024). This puts the government under pressure. In this scenario, the provision of tax incentives or government funding is unlikely to occur, at least at the levels of billion dollars needed to construct a big offshore hub. However, several potential funding sources exist, including private sector investment from oil and gas companies, international climate finance mechanisms, green bonds, and partnerships with international organizations and development banks.

Conclusions

Brazil's CCS landscape is increasingly promising due to the alignment of technological knowledge, geographic proximity between CO_2 emission sources and storage sites, and progressive legislation. While the country still faces hurdles in financing and ensuring fast-track regulatory approvals, the successful implementation of pilot projects - such as the Petrobras' offshore injection schemes and onshore initiatives like FS Bioenergy's - indicates Brazil's capacity to progress significantly in the global CCS arena. Continued collaboration between government, industry, and financial institutions is essential for unlocking the full potential of CCS as a key tool in Brazil's decarbonization strategy.

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