# CARBON CAPTURE AND STORAGE

A brief guide on one of the key alternatives for transformation the oil and gas sector in Brazil

Elaboration: epe

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## CCS

CARBON CAPTURE AND STORAGE

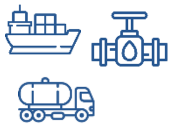
In Brazil, the expected growth in the production of hydrocarbons through the decade faces challenges for the sustainability of the energy sector over the pressures imposed by the already observed climate changes. In this context, Carbon Capture and Storage technologies (CCS) emerge as key tools so that the goals defined in international environmental agreements are met, while the alternatives related to renewable sources can expand their reach in society, maintaining the energy security, and increase their participation in the energy matrix.

This document presents what are the main pillars that should guide the discussion of carbon storage projects in Brazil.

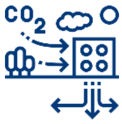
Clarification of concepts is essential to the transparency and credibility for planning activities that require sustainability and harmony with the environment and society's knowledge.

The value chain of $CO_2$ projects involves the following main steps:

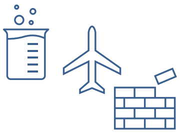
**CAPTURE**
Technologies that capture $CO_2$ directly from the air or from sources such as industrial plants.



**TRANSPORT**
Movement of compressed $CO_2$ from the point of capture to the point of storage and/or use.




**STORAGE**
Subsurface storage, in onshore or offshore, geological formations.

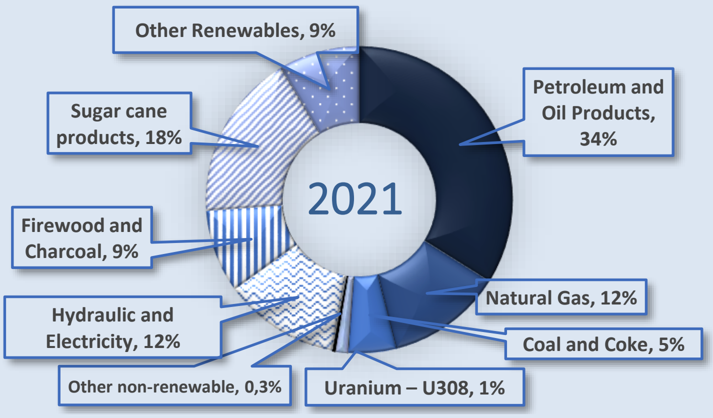


**USE**
Utilization of $CO_2$ as an input for products or services.

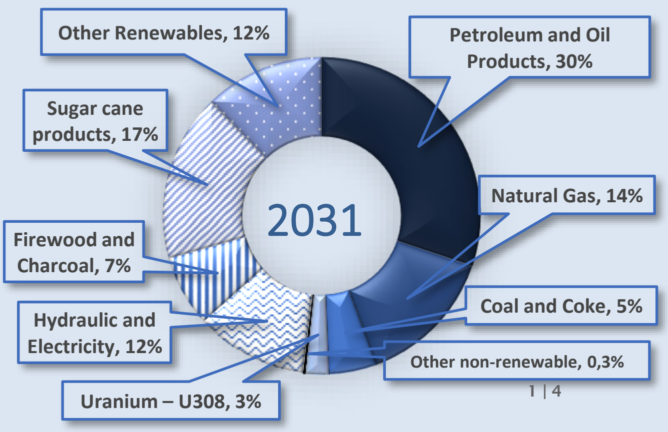
The acronym CCS is restricted to capture and storage processes. When referring to the capture and subsequent use of $CO_2$, the acronym is CCU ("Carbon capture and utilization"). To refer to the complete process, which involves capture, utilization and storage, then there is the acronym CCUS ("Carbon capture, utilization and storage").

## BRAZILIAN ENERGY MATRIX

Source: EPE (2022)




The forecast for the next decade is a 28% growth in demand, but the energy matrix will maintain its highly renewable characteristic!



# TECHNIQUE

Basic criteria that must be considered when selecting storage areas.

Depending on specific geological properties, several types of formations can be used to store $CO_2$. Among the main sites/types of underground storage are: oil and gas reservoirs, in active or depleted fields; geological formations containing highly saline water (saline reservoirs); unmineable coal deposits; shale rich in organic matter and basalt. Because they can support much larger volumes when compared to other options, oil and gas reservoirs and formations with highly saline waters are those bearing the most advanced projects in the world.

Oil and natural gas accumulations are associated with deep saline reservoirs!

## SALINE RESERVOIRS

### WHAT IS IMPORTANT TO UNDERSTAND!

Saline reservoirs are commonly cited as one of the options for $CO_2$ storage sites. It is important to clarify, however, that they are restricted to deep formations, far from freshwater aquifers, formed by layers of porous rock filled with water with salinity higher than 10,000 mg/L of total dissolved solids. This represents a level of water unfit for drinking or use.

Source: DOE. NETL (2017)

The process of capturing stationary sources can be done through different methods, including absorption, adsorption, membranes, cryogenics and oxyfuel.

In the site identification phase, the volumetric capacity of each must be observed. Site selection must be accompanied by plans to monitor the stored $CO_2$ to prevent leaks.

The stage of characterization and selection of storage sites must involve, at minimum, the following information:

**TYPE AND QUALITY OF THE RESERVOIR**
Porosity (> 15%), permeability (> 10 mD) and effective thickness (> 15 m) are essential to know the injection and storage capacity. Since the gas storage takes place in a supercritical state, the minimum estimated depth of the reservoir must be 800 meters. Homogeneous layers are ideal.

**EXISTENCE OF SEALING ROCK**
Recognizing the presence and thickness (preferably greater than 50 m) over the reservoir is essential.

**FAULT OR FRACTURE MAPPING**
Aimed at identifying the integrity of trapping structures and eliminating the risk of $CO_2$ leaks.

**LOCAL TECTONIC**
Low seismicity must be prioritized in order to guarantee the project integrity.

**GEOLOGY AND GEOPHYSICS DATA COVERAGE**
The existence of 2D and 3D seismic surveys, as well as exploratory wells with digital logs, contribute to the to the sites' characterization..

**DRILLED WELLS DENSITY**
The interference with the layers of sealing rocks compromises the unity of the storage structure. Abandoned and preserved wells must be selected, avoiding competition with active productions.

Source: NPD/NO. (2014); DOE/NETL (2017)

## USING $CO_2$ TO INCREASE PRODUCTION

The use of $CO_2$ to improve hydrocarbon recovery is often mentioned in discussions about $CO_2$ storage. In Brazil, the technique of enhanced oil recovery (EOR) has been applied by Petrobras for years in the pre-salt fields. The project developed by the company stands out for being the first one to separate $CO_2$ associated with natural gas in ultra-deep waters, registering, in a water depth of 2,200 m, the record for the deepest $CO_2$ gas injection well.

Around the world, enhanced recovery techniques through $CO_2$ injection for coalbed methane (enhanced coalbed methane - ECBM), natural gas (enhanced gas recovery - EGR) and gas hydrate (enhanced gas hydrate recovery - EGHR) are still being developed or tested in pilot scale.

# LOGISTICS

The availability of infrastructure to safely and reliably transport, inject and monitor $CO_2$ is vital to enable any carbon storage project to be implemented. The main factors to be considered in planning projects for CCS are:

## Existing and Planned Infrastructure

*Supply, Processing and Transportation*

- REFINERIES AND PETROCHEMICAL PLANTS
- NATURAL GAS PROCESSING PLANTS
- THERMAL POWER STATIONS
- LNG TERMINALS
- HARBORS
- GAS PIPELINES
- TRANSMISSION LINES
- HIGHWAYS
- RAILWAYS

Pipeline and maritime routes are the two main options for large-scale transportation, with the use of ships being restricted, still in the testing phase, very similar to the transport of liquefied petroleum gas (LPG) and liquefied natural gas (LNG). The use of trucks and trains is not yet economically viable, however this possibility is suggested for short distances and small volumes of $CO_2$.

Despite the particularities of each type of fluid, the reuse of gas pipelines for the transport of $CO_2$ is cheaper than the construction of new lines.

Although adaptations are inevitable, the operating pressure and the estimated service life (especially based on corrosion) are the main parameters to be evaluated in the reuse of decommissioned pipelines.

The sharing of infrastructure (transport and storage) in hubs is efficient in environmental, economic and social terms for decarbonization and reduction of the carbon footprint.

## Sources and Market

- REFINERIES
- NATURAL GAS PROCESSING PLANTS
- THERMAL POWER STATIONS
- PLATFORMS AND FPSOs
- PETROCHEMICAL INDUSTRY
- ETHANOL PLANTS
- CHEMICAL INDUSTRY
- STEEL AND CEMENT
- PAPER AND CELLULOSE
- MINING

Decarbonization involves a set of actions related to the avoidance, reduction or compensation of Greenhouse Gases (GHG) emissions.

The term "carbon footprint" refers to the total amount of GHGs (including carbon dioxide and methane) generated by anthropogenic actions.

Around the world, governments play a fundamental role in stimulating investments in public-private partnerships for projects that integrate capture, storage and use.

Countries such as Germany, Canada, China, United Arab Emirates, United States, Japan, Norway and the United Kingdom are among those leading the most advanced pilot projects.

The recognition of the proximity to the main emission sources and markets that can take advantage of storage is part of the strategic selection of sites for CCS and eventually CCUS.

Source: The Carbon Sequestration Leadership Forum (CSLF, 2021)

Carbon storage can be an ally for the strategic positioning of the Brazilian energy sector in the face of international movement for the necessary changes in energy use, reduction of anthropogenic greenhouse gas emissions and the impacts mitigation of climate change. The development of strategic plans, policies, regulations and national, regional or local financial mechanisms related to the activity is part of the Brazilian government's agenda.

Since 2009, through the establishment of the National Policy on Climate Change (PNMC, Law No. 12,187/2009), Brazil has been discussing what would be the best measures to promote the dissemination of technologies, processes and practices capable of reducing emissions or promoting greenhouse gas sink removals.

The repositioning of Oil and Gas activities in the face of climate discussions, including promoting the capture and storage of $CO_2$, has been the target of specific regulatory efforts by the Federal Government.

| Decree No. 11.075/2022 | CNPE Resolution No. 05/2022 | Law Project No. 1,425/2022 |
|---|---|---|
| Establishes the procedures for the preparation of Sectoral Plans for the Mitigation of Climate Change, institutes the National System for Reducing Greenhouse Gas Emissions (GHG). | Establishes measures to stimulate the development and production of fields or marginal accumulations. Regulation and proposal to mitigate GHG emissions from mature fields. | Disciplines the exploration of the permanent storage activity of $CO_2$ in geological or temporary reservoirs, and its subsequent reuse. |
| Published on 05/19/2022 | Published on 06/23/2022 | In progress (approved by the Infrastructure Services and Environment Commissions) |

## CCS IN BRAZILIAN OIL AND GAS SECTOR HORIZON

The participation of the oil and gas sector in the national energy mix will remain significant in the medium and long term, due to economic aspects, industry supply and road transport. However, for a more sustainable, environmentally conscious and socially democratic future, productions must advance through a decarbonization process, with CCS being a recognized alternative. Multidisciplinary dialogues are essential for the responsible assessment of the opportunities, challenges and cost effectiveness of capturing, transporting, storing and using greenhouse gases.

In addition to contributing to the energy transition, favoring processes that culminate in negative emissions, and helping to mitigate those that involve emissions that cannot be avoided, CCS technologies are applied to several industry sectors, as an alternative in meeting the goals and climate targets. They also represent a tactical option for exploring a rapidly growing international business: the carbon credits market. The Law Project n. 412/2022, aimed at regulating the Brazilian Market for Reducing Emissions (MBRE) of gases that cause the greenhouse effect, is currently pending in the National Congress.

On the other hand, there is also the generation of economic value through the retention of jobs from the oil and gas sector, as well as the creation of new jobs with the adaptation and development of accumulated expertise. The impact is particularly relevant on a local and regional scale, in the direct vicinity of storage projects, being an important way to promote the energy transition with social responsibility.

Furthermore, the reuse of structures in the hydrocarbon industry is an important component for the real sustainability of the sector, helping to reduce the costs and environmental footprint of decommissioning these facilities.

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