CCUS IN LATIN AMERICA

CCUS Conference Week

“Whole Value Chain Carbon Capture, Utilization and Storage (CCUS)”

Pedro Nel Benjumea Hernández
Department of Process and Energy – Faculty of Mines
National University of Colombia – Medellín Campus

Presentation Outline

1. Introduction
2. Latin America (Latam) at a glance
3. Common barriers and perspectives
4. The Brazilian perspective
5. The Colombian perspective
6. Final remarks

Where we come from

National University of Colombia-Medellin campus.

Faculty of Mines (former National School of Mines) was founded in 1887

Who we are

Research group in Surface Phenomena Michael Polanyi

Research group in hydrocarbon Reservoirs.

Line of research: NanoTech Applied to IOR, EOR and CCUS Processes

Who I am

Professor in petroleum engineering since 32 years ago

Former dean of the Faculty of Mines (2015-2018)

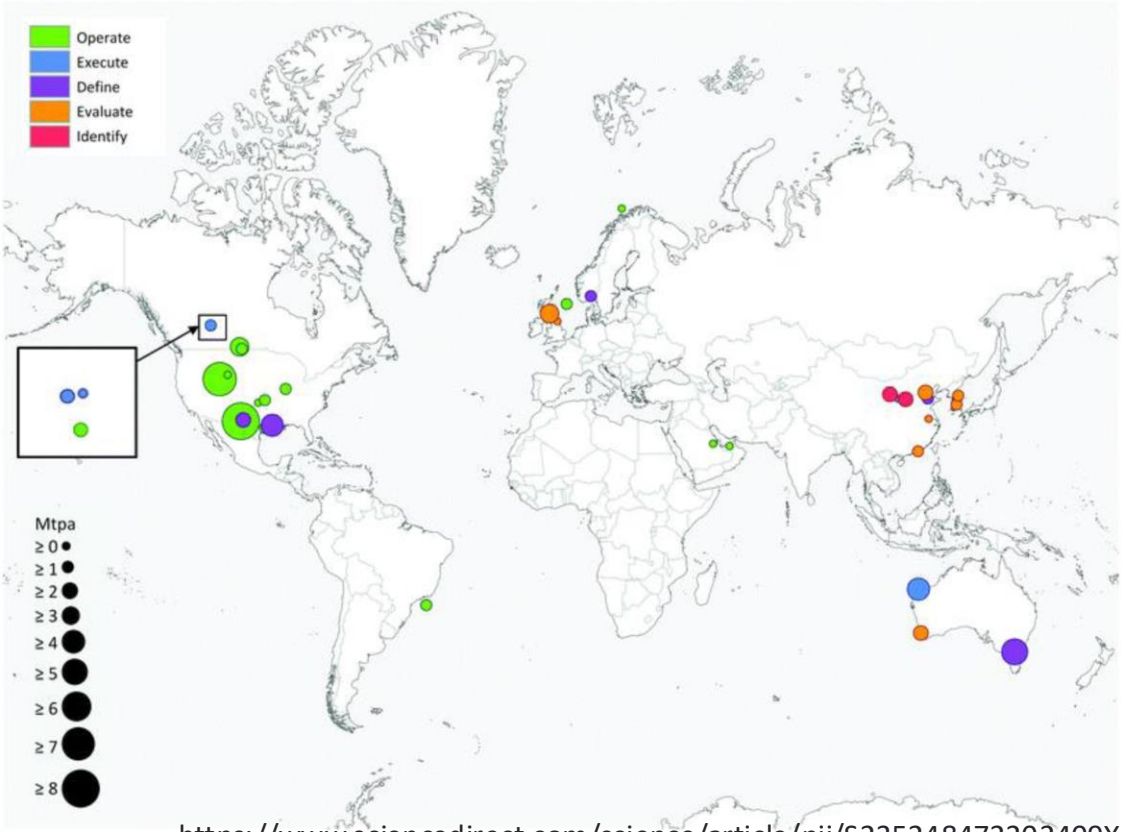
Former director of the Petroleum Colombian Institute (Ecopetrol S.A.) (2023-2024).

Why we are here

"CO_2-EOR for CCUS in Colombia and Ecuador- Norwegian energy initiative".

A collaboration project under the Norwegian programme for capacity development in higher education and research for development (NORHED II).

What challenges we have

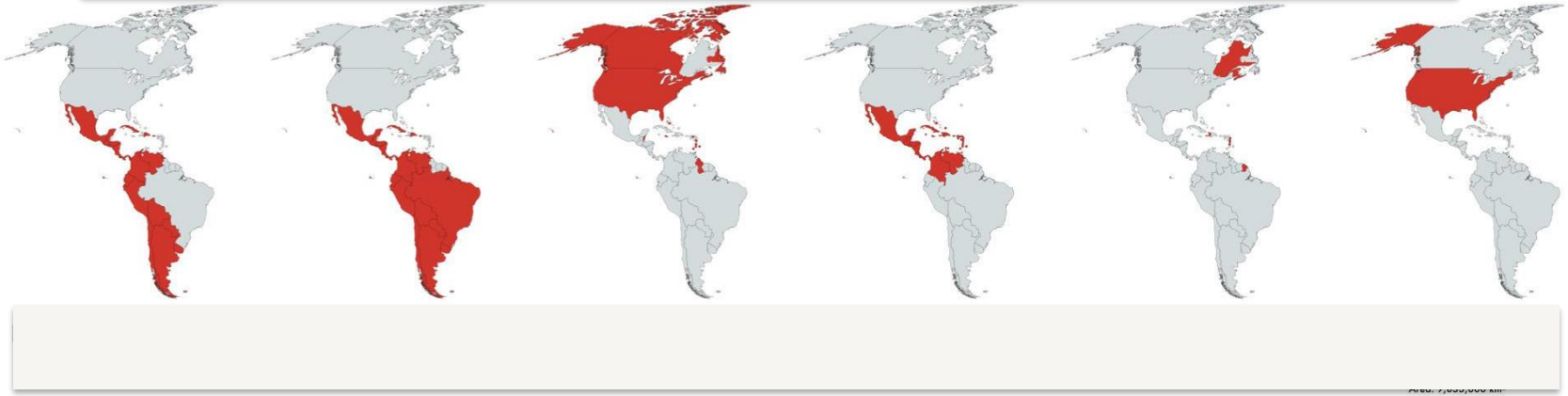


https://www.sciencedirect.com/science/article/pii/S235248472202409X

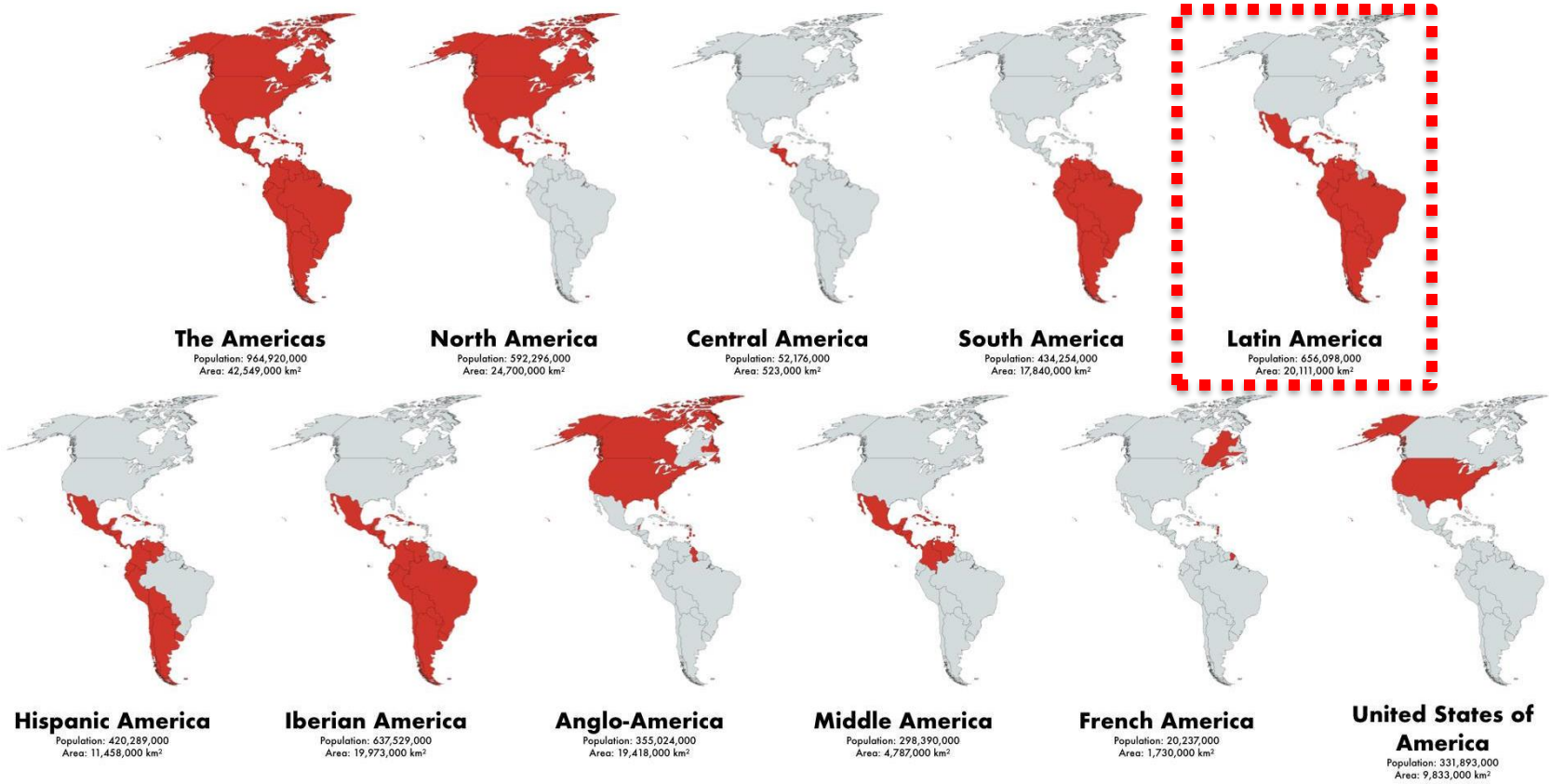
Presentation Outline

1. Introduction
2. Latin America (Latam) at a glance
3. Common barriers and perspectives
4. The Brazilian perspective
5. The Colombian perspective
6. Final remarks

2. Latin America at a glance

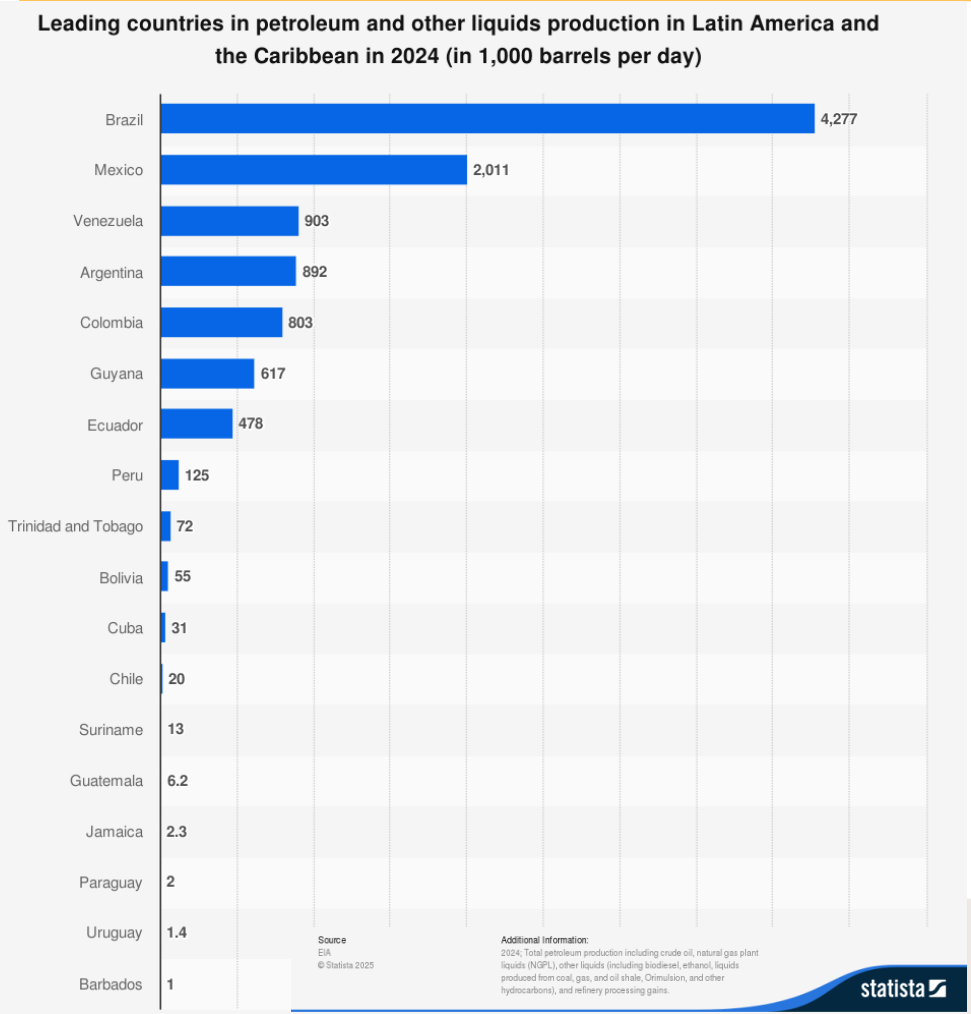


2. Latin America at a glance



- ✓ Latin America (LATAM) consists of 33 countries.
- ✓ **Brazil** is the largest and most populous country in Latin America (212 million people). It also has the region's biggest economy.
- ✓ **Mexico** is the largest and most populous Spanish-speaking country in the world (130.9 million people).
- ✓ **Colombia** is the corner of South America with coasts on both oceans. (Approximately 53 million inhabitants).
- ✓ Approximately **659** million people live in LATAM

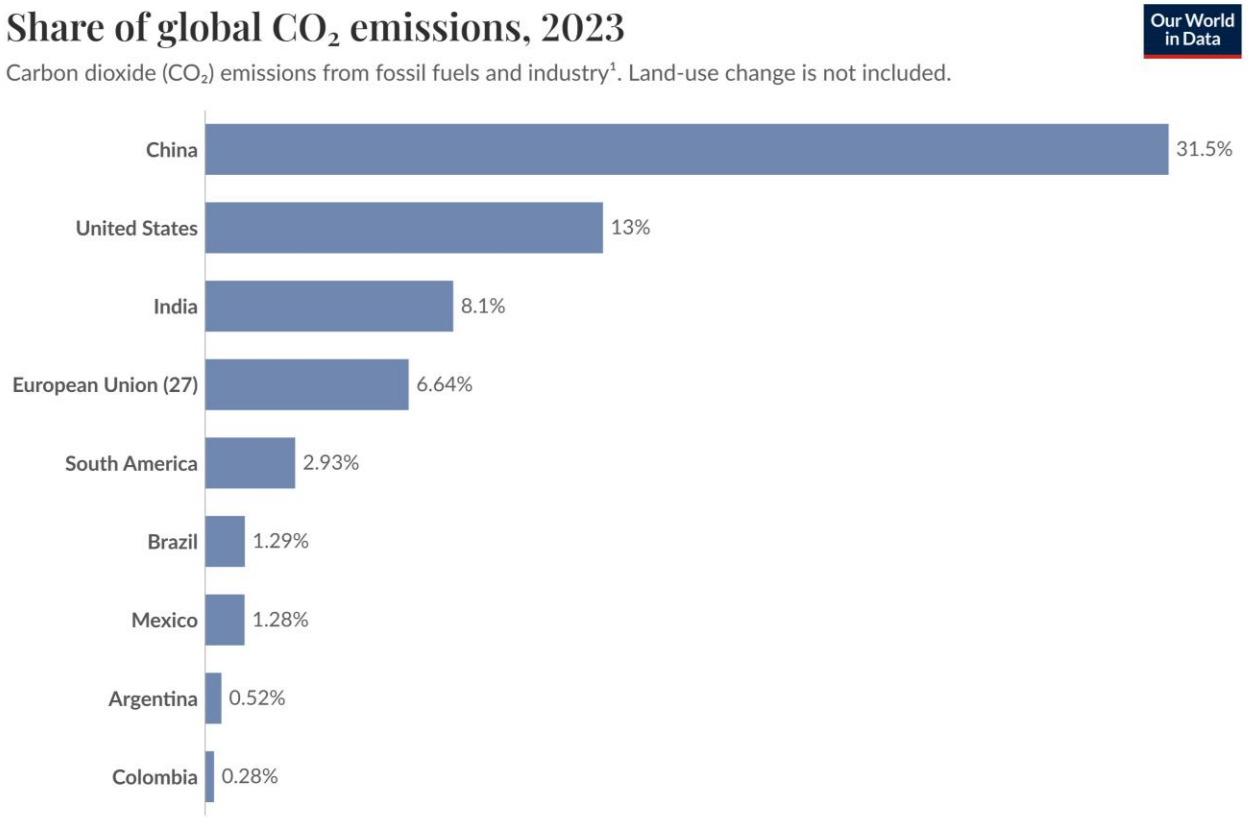
https://www.worldatlas.com/geography/latin-american-countries.html



Oil Production

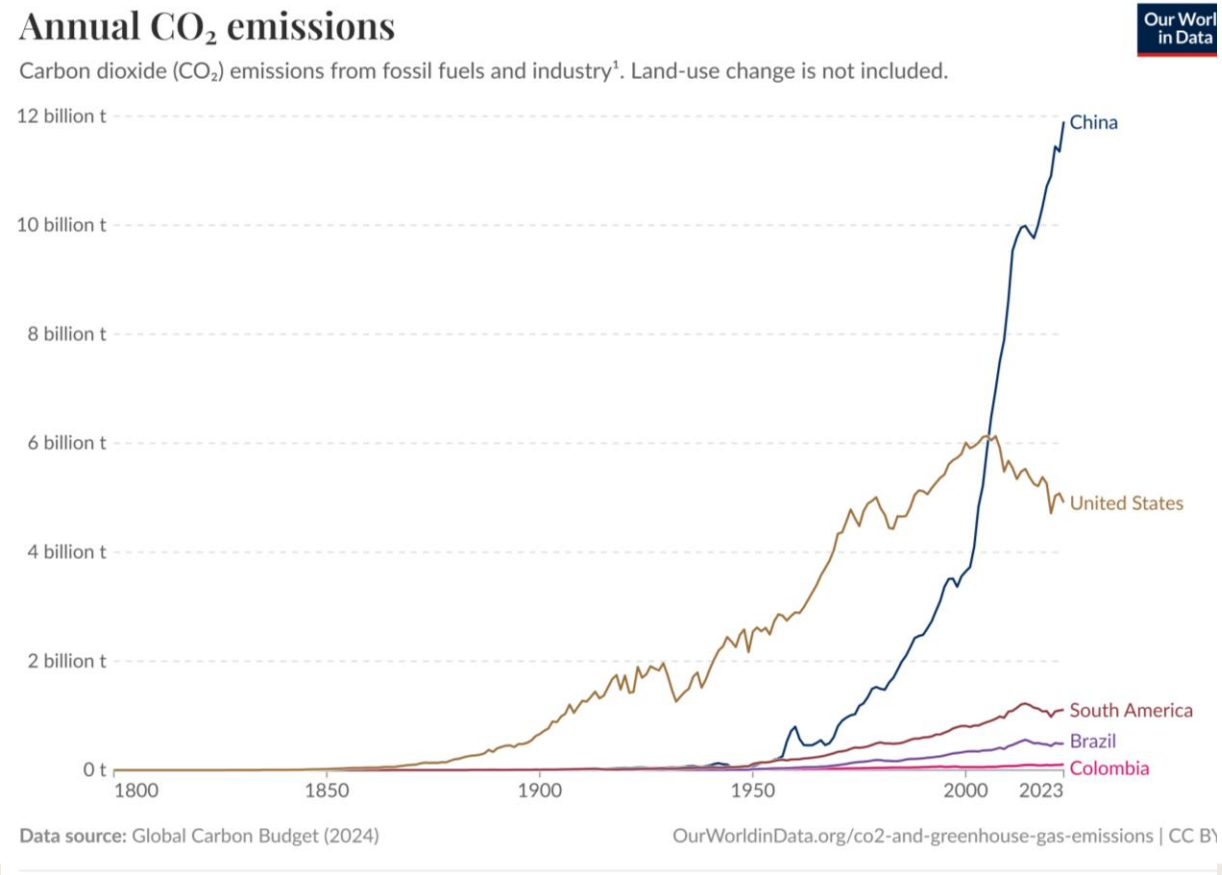
- ✓ In 2024, LATAM accounts for about 9% of the global market share of oil production, close to 8 million barrels per day.

UNIVERSIDAD NACIONAL DE COLOMBIA



CO_2 Emissions

- ✓ LATAM accounts for about 8% of global CO_2 emissions (including Land-use change). Similar to the contribution of the cement industry.

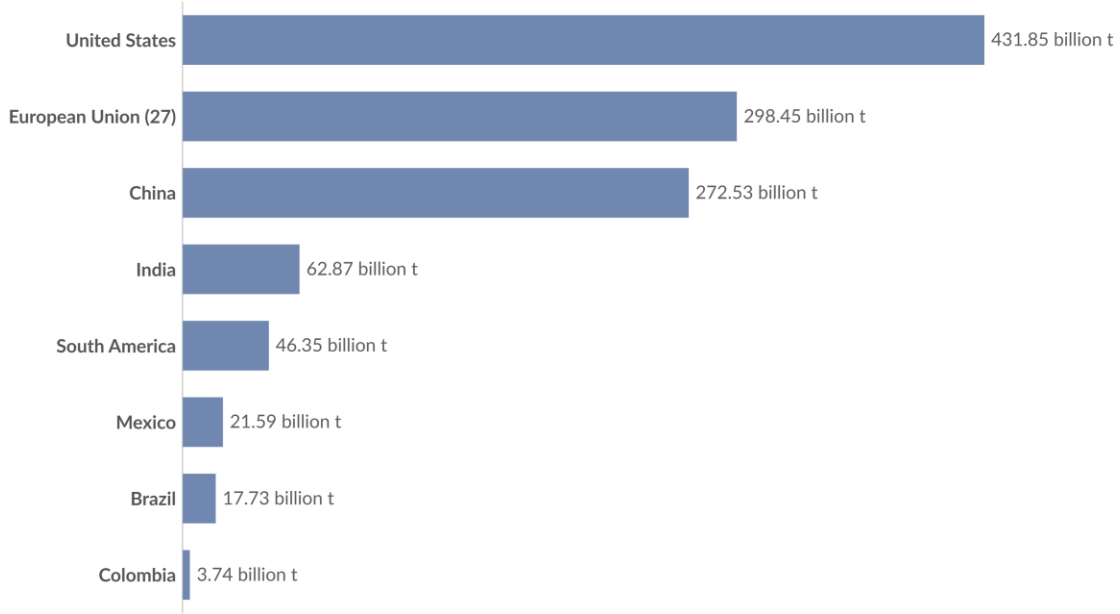


CO_2 Emissions

Cumulative CO_2 emissions, 2023

Our World in Data

Running sum of CO_2 emissions produced from fossil fuels and industry[1] since the first year of recording, measured in tonnes. Land-use change is not included.



Data source: Global Carbon Budget (2024)

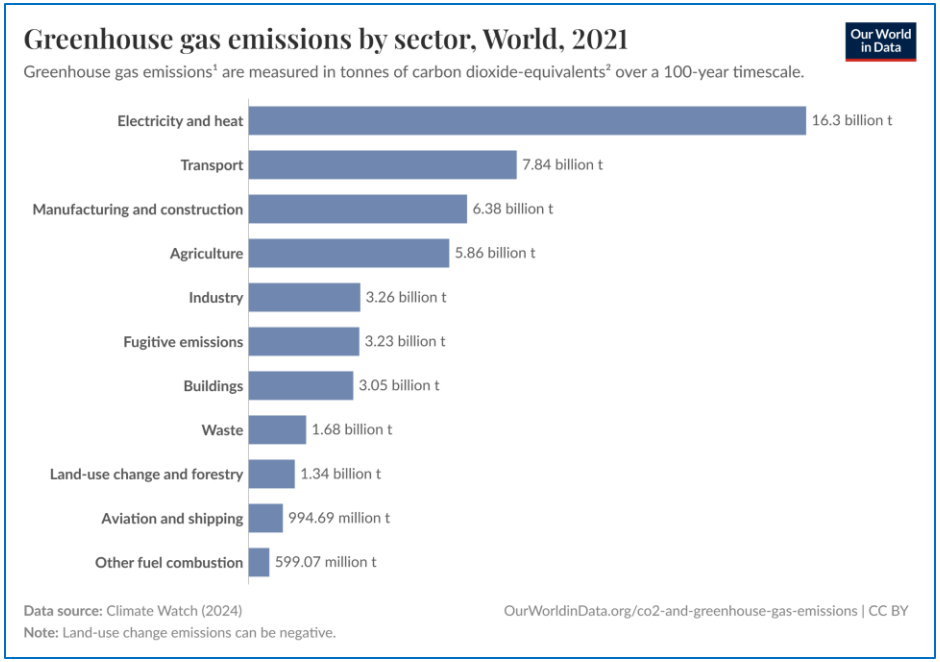
OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

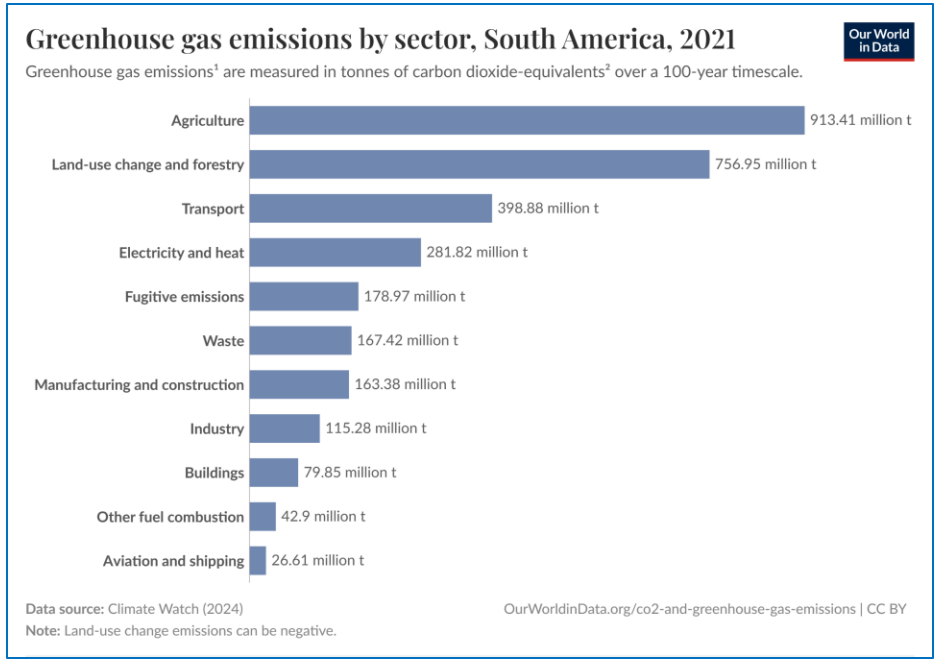
1. Fossil CO_2 emissions This refers to the carbon dioxide released when burning fossil fuels or from certain industrial activities.
Burning fossil fuels — coal, oil, and gas — produces CO_2 during transport (cars, trucks, planes), electricity generation, heating, and energy use in industry. This also includes flaring, which is the burning of extra gas during oil and gas extraction.
Some industrial processes also release CO_2. This happens especially in cement and steel production, where chemical reactions (unrelated to burning fuel) produce carbon dioxide.
These figures don't include CO_2 emissions from changes in land use, like deforestation or reforestation.

CO_2 Emissions

UNIVERSIDAD NACIONAL DE COLOMBIA

CO_2 emissions by sector

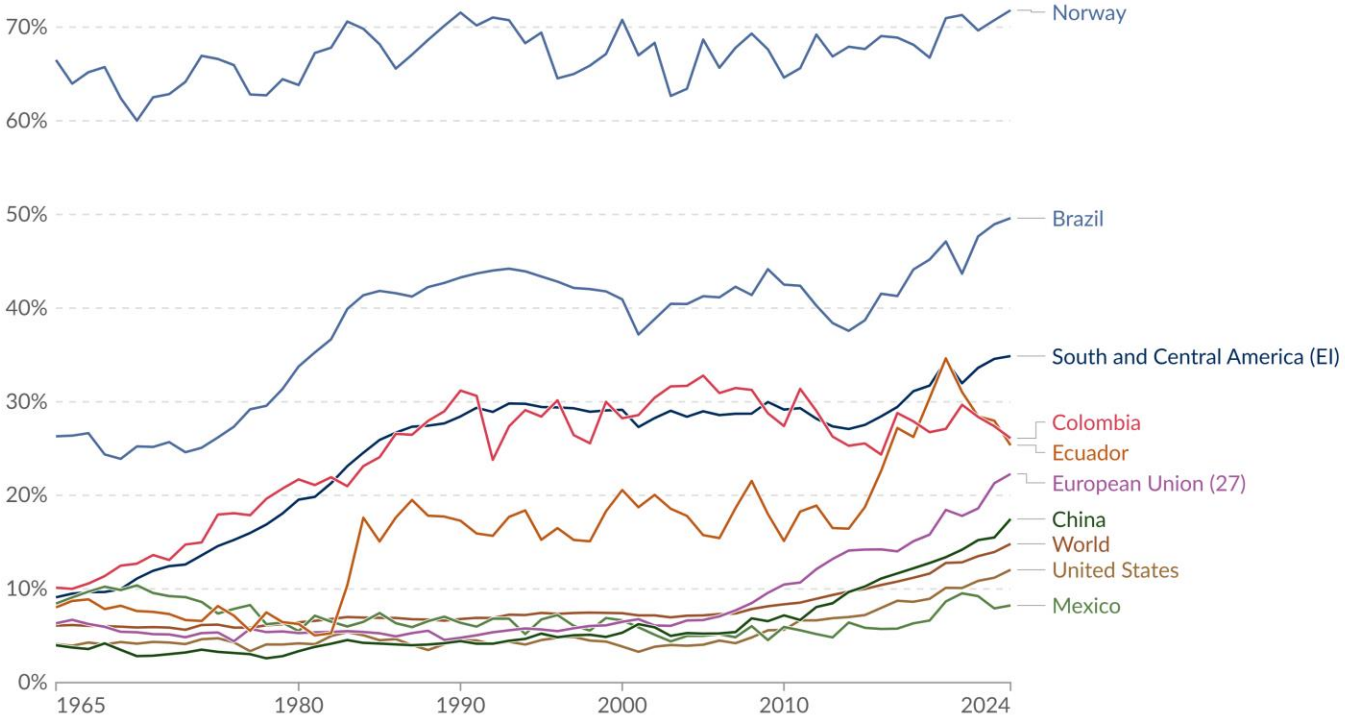




Share of primary energy consumption from renewable sources

Our World in Data

Measured as a percentage of primary energy[1] using the substitution method[2]. Renewables include hydropower, solar, wind, geothermal, bioenergy, wave, and tidal, but not traditional biofuels, which can be a key energy source, especially in lower-income settings.



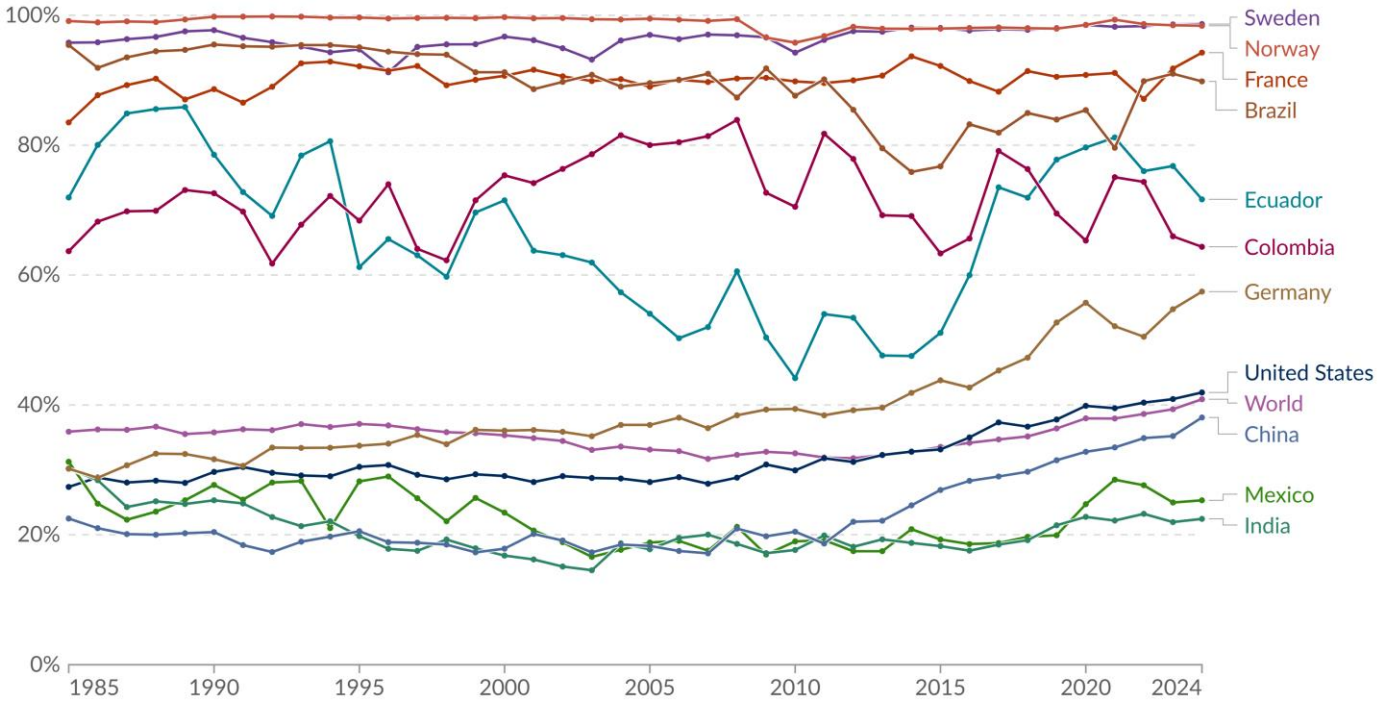
Data source: Energy Institute - Statistical Review of World Energy (2025)

OurWorldinData.org/energy | CC BY

Share of electricity generated by low-carbon sources

Our World in Data

Measured as a percentage of total electricity produced in the country or region. Low-carbon sources correspond to renewables and nuclear power, that produce significantly less greenhouse-gas emissions[1] than fossil fuels. Renewables include solar, wind, hydropower, bioenergy, geothermal, wave, and tidal.



Data source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025)

OurWorldinData.org/low-carbon-electricity-by-country | CC BY

Presentation Outline

1. Introduction
2. Latin America (Latam) at a glance
3. Common barriers and perspectives
4. The Brazilian perspective
5. The Colombian perspective
6. Final remarks

Common barriers and perspectives

- ✓ The development of CCUS projects is mainly hindered by regulatory gaps, weak incentives and high costs (capital intensity is the obvious obstacle across the value chain). Policy and government support are insufficient or lacking. **Neither carrot nor stick**.

- ✓ Many governments in the region, already burdened with subsidizing fuel consumption, lack the financial capacity to provide the necessary subsidies or tax breaks, such as carbon taxes or offset credits, that are essential to counter the high costs of CCUS technologies. **Most CCUS projects are near-universally a cost rather than a revenue.**

Common barriers and perspectives

- ✓ For the governments and the society, **there can be other decarbonization alternatives** that allow them to meet their environmental commitments, such as **controlling deforestation and land-use change**.

- ✓ Environmental licenses for many projects, including renewable energy developments, can take too long, and the national regulation also requires numerous prior consultations with communities.

- ✓ There is a lack of pipelines infrastructure to transport CO_2.

Common barriers and perspectives

- ✓ Despite the region boasts abundant CO2 storage capacity in saline aquifers and depleted hydrocarbon deposits, with well-studied basins such as Neuquén in Argentina, Campos and Santos in Brazil, and Llanos in Colombia offering promising sites, **there is still a lack of centralized and publicly accessible information on the key technological aspects**, which hinders stakeholders from making informed decisions and slows down the adoption of these technologies.

Common barriers and perspectives

- ✓ The existence of a robust biofuels industry is considered a building block for BECCS (bioenergy with carbon capture and storage) projects, which can deliver net-negative emissions by capturing CO2 during plant growth and storing emissions from bioenergy production.

- ✓ The probability of developing significant natural gas reserves allows to develop blue hydrogen projects, using CCUS to support the global shift toward low-emission hydrogen fuels.

- ✓ Existence of industrial clusters with hard-to-abate sectors.

- ✓ Oil and gas companies are being integrated into corporate decarbonization strategies (ESG policies).

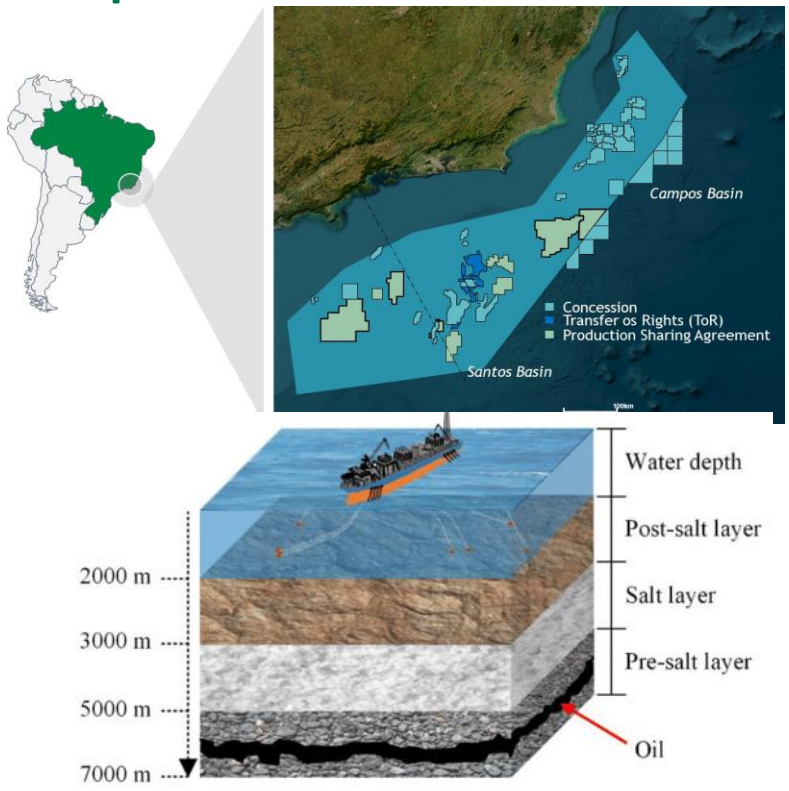
Presentation Outline

1. Introduction
2. Latin America (Latam) at a glance
3. Common barriers and perspectives
4. The Brazilian perspective
5. The Colombian perspective
6. Final remarks

The Brazilian perspective

Big player: Petróleo Brasileiro S.A. (Petrobras)

- ✓ Type of company: government-controlled private company.
- ✓ Share of the Brazilian government: 29.02%.
- ✓ Hydrocarbon production (Q2-2025): 2.91 MMBOED (2.32 MMBOD)
- ✓ Pre-salt fields: 2.2 MMBOED



Source: PublicPresentationofPetrobras https://www.energy.gov/sites/default/files/2023-07/6a.%20CCUS%20at%20Petrobras%20-%20CSLF%20meeting%202023%20_%20final%20version%20PDF.pdf

Brazil is a non-OECD country,
It belongs to the BRICS

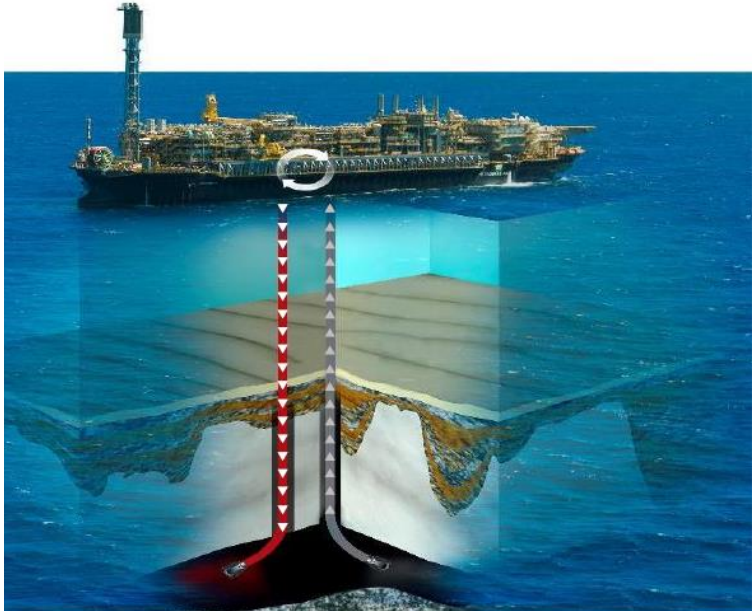
Brazilian developments and prospects

Main developments	CO_2 source	Storage site	Status
CCUS-EOR Pre-salt (Petrobras)	Separation from Associated Natural Gas. High GOR (250 sm^3/m^3), and high CO_2 content (> 20%).	Santos basin: ultra-deep-water reservoirs (mainly heterogeneous microbial carbonates).	Started in 2010. The full-scale CCUS project was in place in 2013.
CCS-Hub pilot (Petrobras)	CO_2 from a gas processing plant.	Hypersaline aquifer.	Demonstration project under evaluation.
Rio de Janeiro CCS-hub (Petrobras)	hard-to-abate sectors	Depleted oil reservoir or saline aquifer.	Future.
FS-BECCS (FS: fuel sustainability)	CO_2 captured from a corn ethanol extraction plant.	On-shore saline aquifer.	Feasibility studies and basic engineering.

CCUS-EOR PRE-SALT

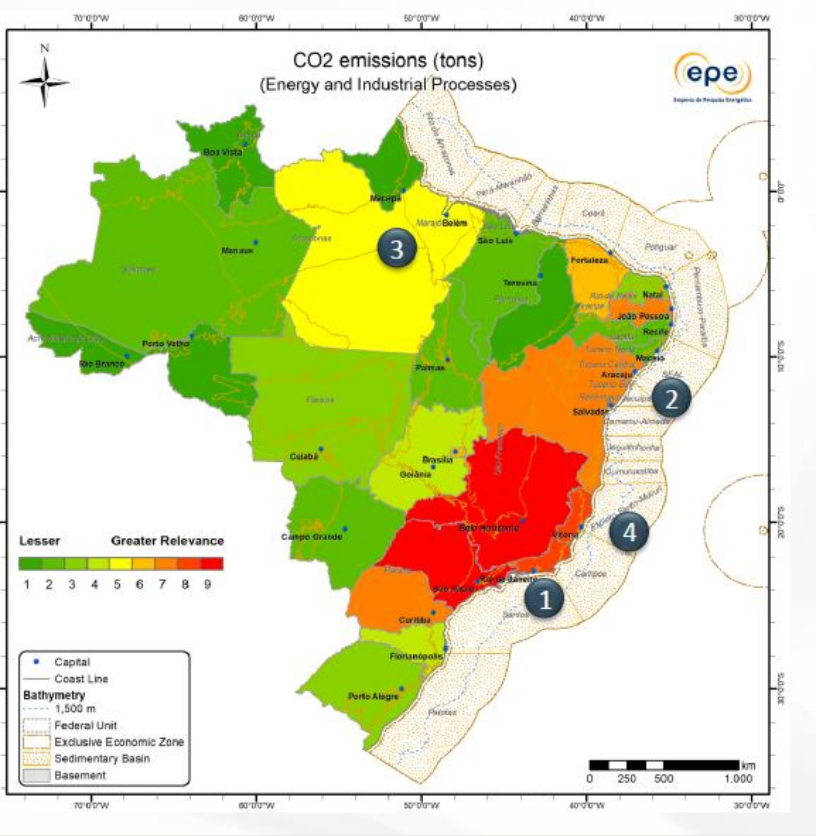
- ✓ First CCUS project in ultra-deep waters.
- ✓ Currently the largest CO_2 injection project in the world (annual reinjection).
- ✓ Until 2022: 40.8 million t CO_2 reinjected (cumulative).
- ✓ Target 2025: cumulative reinjection of 80 million t CO_2 in CCUS-EOR projects (WAG scheme).
- ✓ 21 FPSO (floating production storage and offloading) with CCUS technology.
- ✓ CO_2 capture by polymeric membranes.

Shecaira et al, 2025. CCS: the Brazilian perspective



Deepest offshore well, 2,173 m water depth. Reservoirs are between 5 to 7 thousand meters below the sea level.

CCS-Hub pilot



https://dashboard.epe.gov.br/apps/visualizacaoZoneamento/

Rio de Janeiro state

- Demonstration project under evaluation
- CO2 stream from a gas processing plant
- Storage in a hypersaline aquifer

100,000 tons of CO_2 /year will be injected into the São Tomé formation

Rio de Janeiro state

- CCS Hub with capacity for 25 MtCO2/y
- Selected hard-to-abate clusters
- Ambition to be the first decarbonized region in Brazil

Shecaira et al, 2025. CCS: the Brazilian perspective.

Presentation Outline

1. Introduction
2. Latin America (Latam) at a glance
3. Common barriers and perspectives
4. The Brazilian perspective
5. The Colombian perspective
6. Final remarks

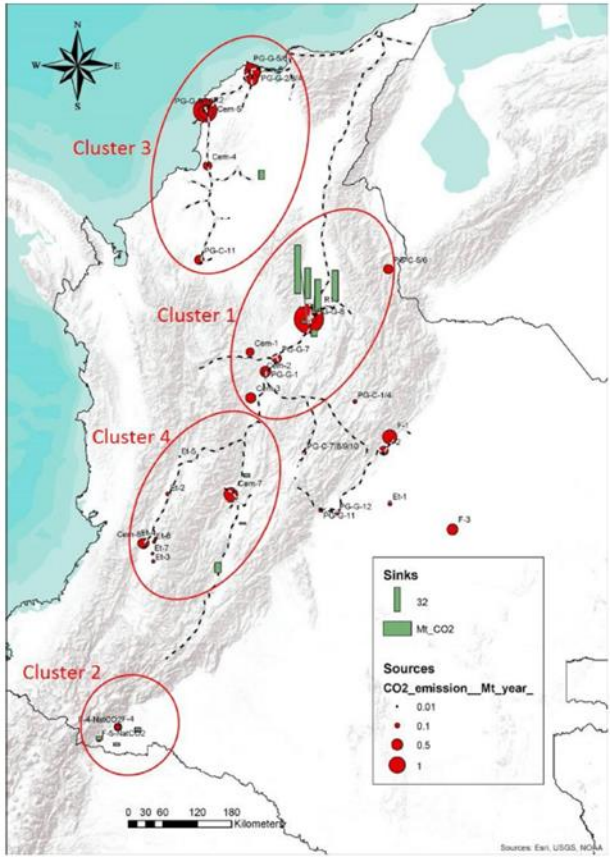
The Colombian perspective

Big player: Ecopetrol S.A.

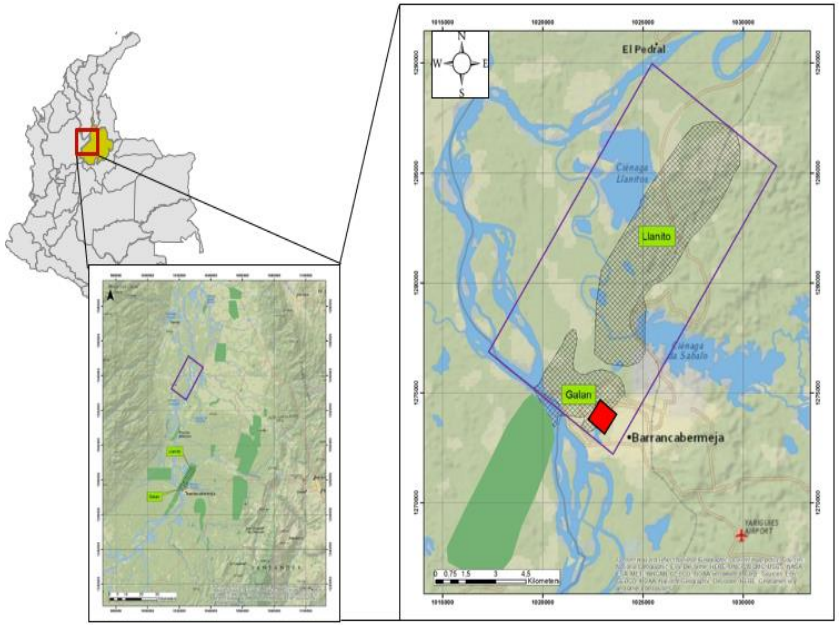
- ✓ Type of company: mixed economy company, majority state-owned.
- ✓ Share of the Colombian government: 88.49%.
- ✓ Hydrocarbon production (Q2-2025): 714,229 MBOED.
- ✓ Llanos basin: almost 70%
- ✓ Permian basin: close to 130 MBOED, 18%.

Colombian prospects

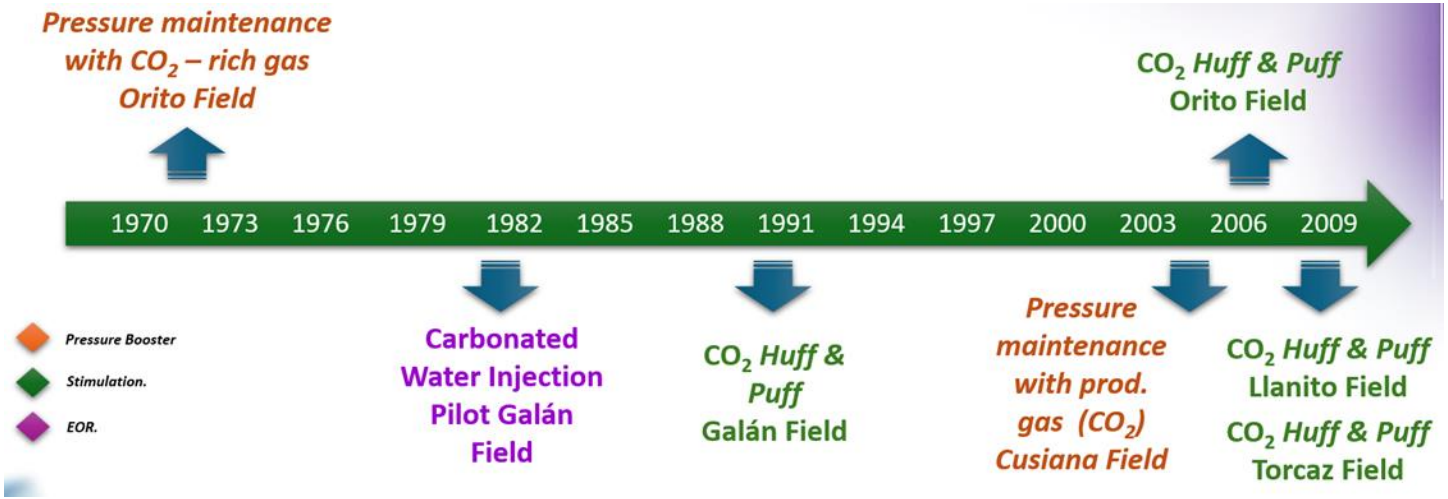
Main prospects	CO_2 source	Storage site	Status
CCUS-EOR (Ecopetrol-Middle Magdalena Valley basin)	Barancabermeja Refinery (CO_2 from grey hydrogen production).	Middle Magdalena Valley basin. Mature oil fields close to the refinery (20 API).	Huff and Puff pilot planned to start 3Q-2025.
CCUS-EOR (Ecopetrol-Llanos basin)	CO_2 from produced gas from a CIS (combustion in situ Thermal EOR project).	Llanos basin, Chichimene Field	Feasibility studies and basic engineering.



Clusters of CO_2 sources and sinks for CCUS projects in Colombia. Yañez, E. et al. (2020).



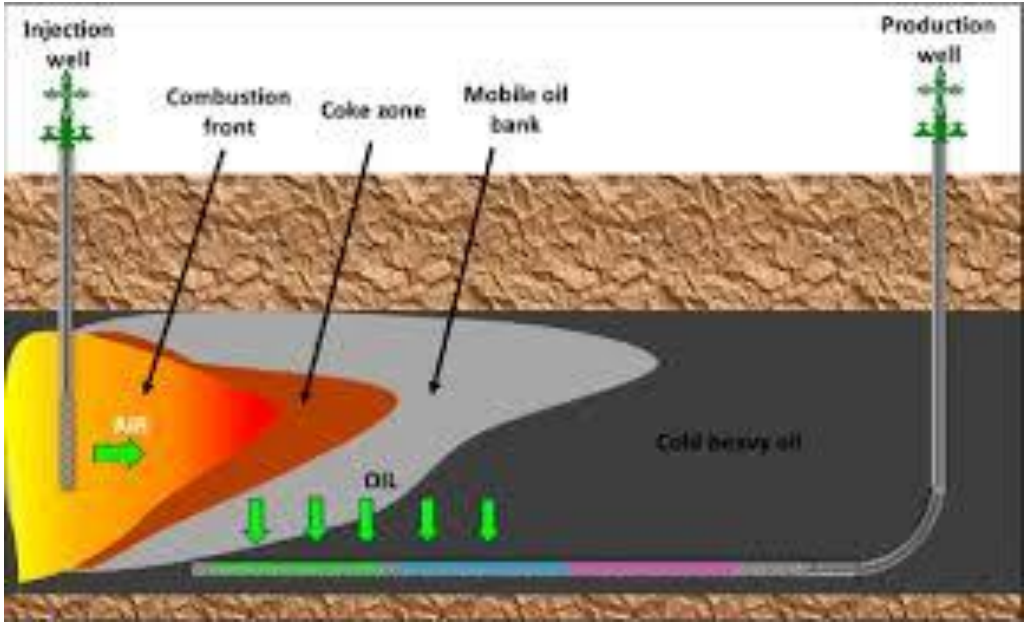
Ecopetrol previous pilot projects CO2-EOR



CO_2 purchased to industrial suppliers

The Chichimene in situ combustion (ISC) project is a successful pilot-scale enhanced oil recovery (EOR) project iwhich began in September 2019. It is notable as the first ISC trial in a deep (8,000 ft), heavy oil (9° API) reservoir in Colombia.

The expansion project has the potential to enable contingent reserves of almost 900 MBOPD.



https://pubs.acs.org/doi/10.1021/acs.energyfuels.3c05067

Produced gas

- ✓ Complex mixture
- ✓ Composition changes as the process advances.

CO_2 capture and injection in another deeper sand formation (20 API oil).

Injection of produced gas in a closed cycle.

Presentation Outline

1. Introduction
2. Latin America (Latam) at a glance
3. Common barriers and perspectives
4. The Brazilian perspective
5. The Colombian perspective
6. Final remarks

Final remarks

- ✓ Due to its particular conditions regarding GHG emissions, for latam, decarbonization must be the big umbrella (carbon credit certification) and energy transformation one of the means (decreasing carbon intensity of the energy).

- ✓ The goal of energy transformation is to diversify the energy mix without sacrificing energy security.

- ✓ Energy transformation must be driven by demand and the specific characteristics of each energy market.

Gracias

Universidad Nacional de Colombia