

# **PS** Launching a BECCS Project in Brazil: Developing a Low-Carbon Energy Complex from Sugarcane Biomass

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## **Abstract**

This paper announces the launch of a Bioenergy with Carbon Capture and Storage (BECCS) project led by Eneva, in cooperation with the Institute of Petroleum and Natural Resources (IPR/PUCRS) and Adecoagro. The project aims to develop alternatives for low-carbon electricity generation from sugarcane biomass, integrated with CO<sub>2</sub> capture and geological storage. Its scope includes evaluating CO<sub>2</sub> capture technologies for cogeneration and ethanol fermentation, identifying suitable geological formations for long-term storage, and developing a Monitoring, Measurement, and Verification (MMV) plan. Additionally, the project will structure carbon credit certification and prepare a pilot site to test BECCS technologies under real operational conditions, with the overarching goal of accelerating Brazil's transition toward a low-carbon and negative-emission energy matrix. The project adopts a multidisciplinary approach combining process engineering, geoscience, and sustainability assessment. Initial steps involve mapping CO<sub>2</sub> sources from sugarcane processes and evaluating capture technologies adaptable to industrial cogeneration and fermentation systems. A preliminary geological assessment will model suitable storage formations, supported by a digital geodatabase. Methodologies for MMV, GHG inventories, and carbon credit validation will be designed to create a replicable model for future BECCS initiatives in Brazil. Early outcomes will include the characterization of CO<sub>2</sub> streams, identification of feasible capture routes, and preliminary classification of potential storage reservoirs. The integrated MMV strategy and digital geological database will support pilot tests and future full-scale deployment. Expected impacts include strengthening Brazil's technical readiness for BECCS, fostering academia–industry collaboration, and supporting the national carbon neutrality agenda. This initiative represents one of the first concerted efforts in Brazil to develop an integrated BECCS system from concept to implementation, combining the expertise of Eneva, IPR/PUCRS, and Adecoagro. Its novelty lies in coupling CO<sub>2</sub> capture from ethanol fermentation with biomass-based cogeneration, creating a new technological route for negative-emission power. By announcing this initiative, the paper highlights Brazil's potential to lead BECCS innovation in the Global South and reinforces its commitment to low-carbon technologies and sustainable energy systems.

### Background/Context

Conceptually, Bioenergy with Carbon Capture and Storage (BECCS) is frequently cited as one of the most promising Carbon Dioxide Removal (CDR) approaches for near-term implementation in the transition toward net-zero energy systems. This perspective is supported by several key arguments. **Biomass-based power plants** can generate electricity while **providing firm, dispatchable power** to support large-scale electricity grids. In addition, these systems can be **integrated with processes that produce liquid or gaseous fuels**, including hydrogen (Clarke et al., 2022). When coupled with carbon capture and geological storage, the **CO<sub>2</sub> emissions** generated throughout the biomass energy production chain can be **permanently stored** (Figure 1), resulting in **high-integrity negative emissions** (Fuss et al., 2018).

# BECCS

Bioenergy + Carbon Capture and Storage

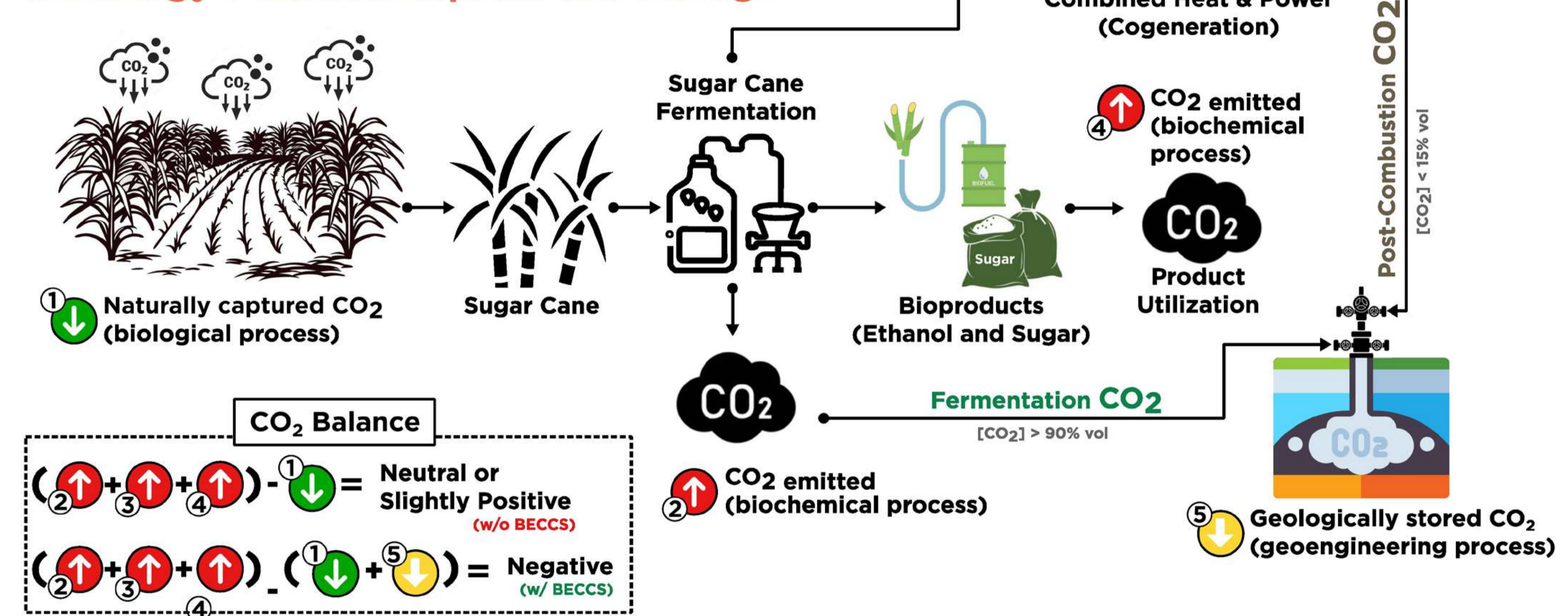


Figure 1 Conceptual workflow of a BECCS system associated with bioenergy production, showing CO<sub>2</sub> streams generated during ethanol fermentation and combined heat and power (cogeneration) processes and their integration with carbon capture and storage.

A recent study found that BECCS from fermentation alone could remove up to **20.0 Mt-CO<sub>2</sub>/year** (if widely implemented, > 267 units), with an average capture of **75 kt CO<sub>2</sub>/year per bioenergy plant** (Pereira et al., 2025). However, in Brazil - the world's second-largest ethanol producer, with more than **375 ethanol-producing units and 302 biomass power plants** (Figure 2) - **only two projects** have been announced to date (FS Bioenergia - advanced stage, and Usinas Itamarati - early stage). This underscores the **significant opportunity for additional projects to be developed**, including the one proposed in this work.

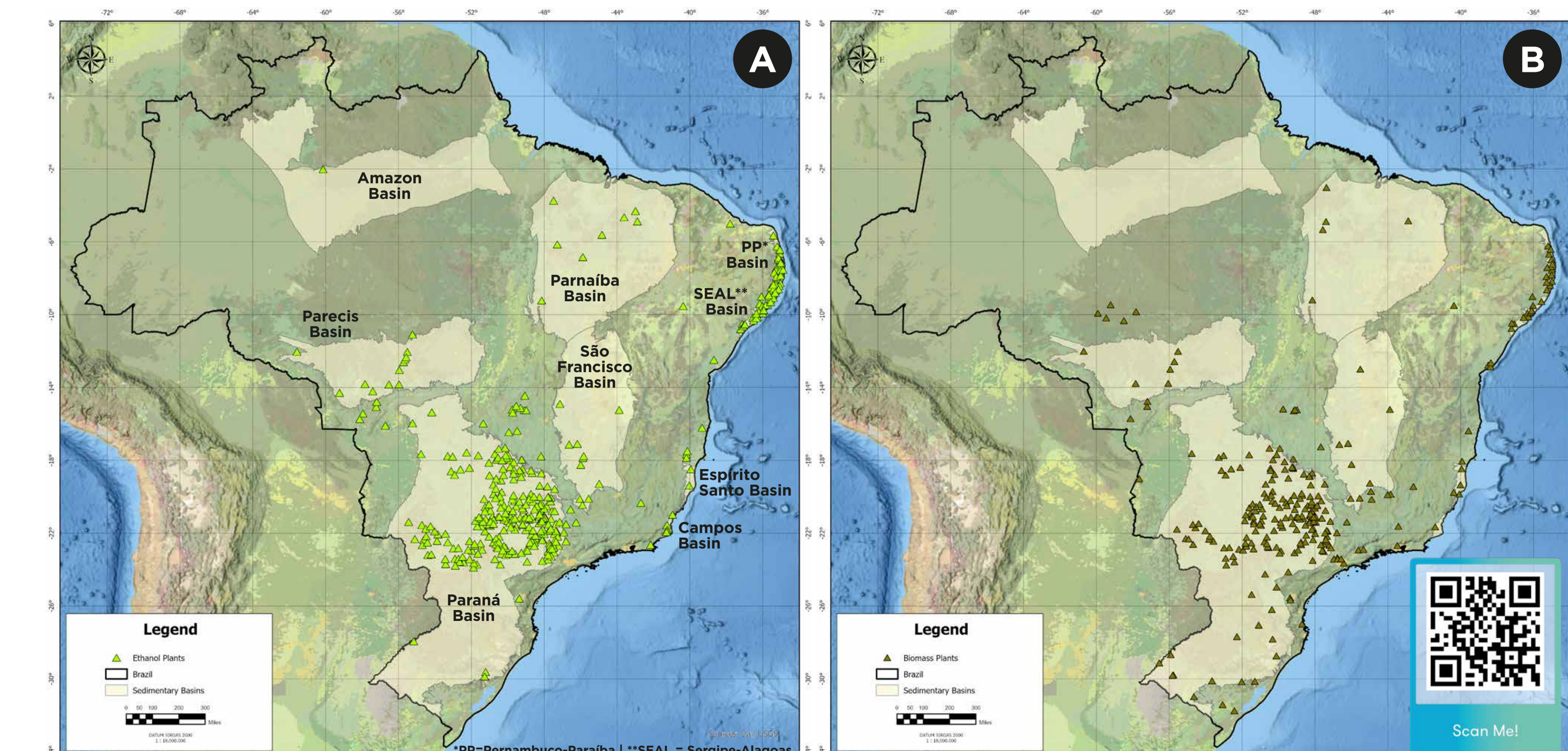


Figure 2. Distribution map of ethanol mills (A) and biomass-based power plants (B). Source: GIS CCUS Brazil Platform.

### Objectives and Scope

The project aims to develop low-carbon **energy and electricity generation** alternatives from sugarcane biomass, **integrated with CO<sub>2</sub> capture and geological storage** at two bioenergy facilities located **Brazil's Center-West Region (Angélica and Ivinhema, MS State)**, within the central portion of the intracratonic **Paraná Basin** (Ordovician-Cretaceous), as shown in Figure 3. The overarching goal is to **accelerate Brazil's transition toward a low-carbon and negative-emission energy matrix**.

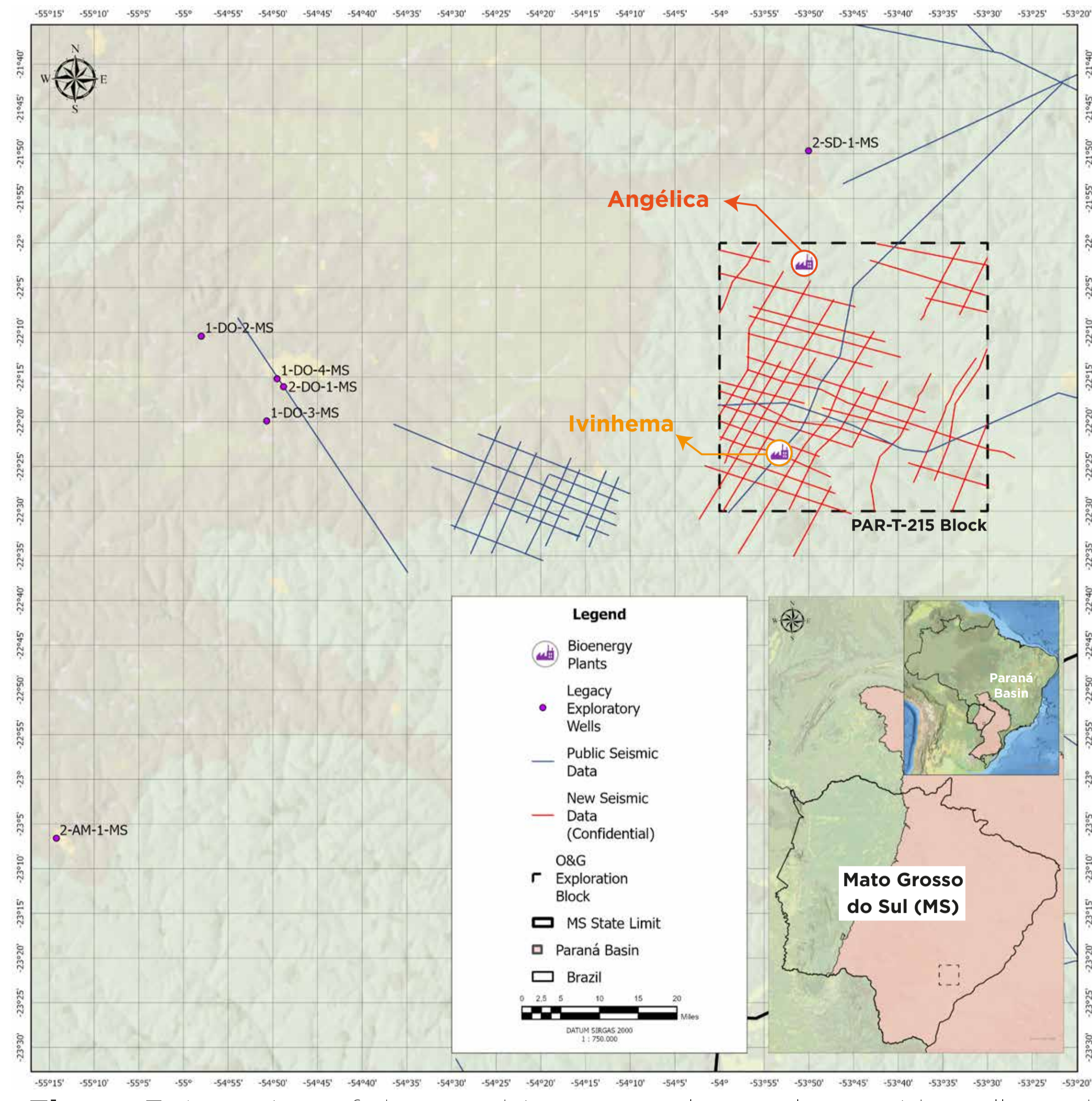


Figure 3. Location of the two bioenergy plants, along with wells and associated geological and seismic data (public and confidential) used in this study.

The project scope includes:

- Characterizing the **CO<sub>2</sub> stream from ethanol fermentation units**, including its **emission profile, impurity content**, and applicable **capture technologies**.
- Characterizing the **CO<sub>2</sub> stream from CHP (cogeneration) units**, focusing on **emission profile, impurity content**, and suitable **capture technologies**.
- Assessing and interpreting **legacy geological data**, as well as both **legacy and newly acquired geophysical data**, to identify **suitable formations** for safe, long-term CO<sub>2</sub> storage.
- Reviewing global **BECCS benchmarks** and developing a **Monitoring, Measurement, and Verification (MMV) and Risk Assessment** plan.
- Structuring a **carbon credit certification pathway** and preparing the **formal validation** of a pioneering **BECCS pilot project** in the **Paraná Basin**.

### Method

A **multidisciplinary approach** integrating **process engineering, geoscience, and sustainability assessment** is being applied. It includes evaluating CO<sub>2</sub> capture technologies for **cogeneration and fermentation**, assessing geological storage potential through a dedicated geodatabase, and developing methodologies for MMV, risk analysis, and carbon credit validation to **support scalable BECCS deployment in Brazil** (Figure 4).

**Project's Title:** Study and Implementation of Strategies for a Low-Carbon Energy Complex Associated with the Sugarcane Production Chain Integrated with Carbon Capture and Geological Storage Solutions (BECCS).

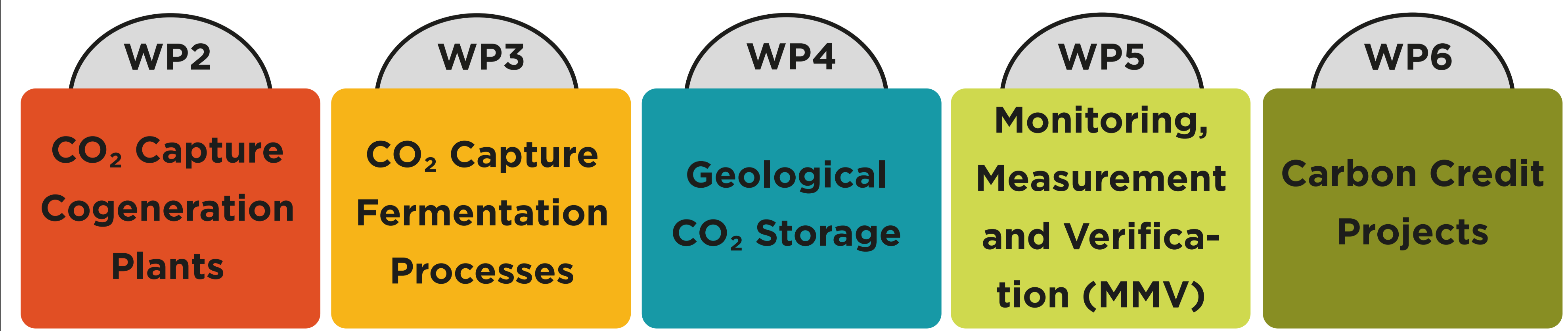


Figure 4. Project's workpackages structure and main tasks. WP1 is related to the project's management activities.

### CO<sub>2</sub> Capture: CHP (Cogeneration) and Fermentation

The overall objective is to implement a carbon capture retrofit at the two bioethanol plants under evaluation, following the main steps shown in Figure 5 to achieve the required purity for certification.

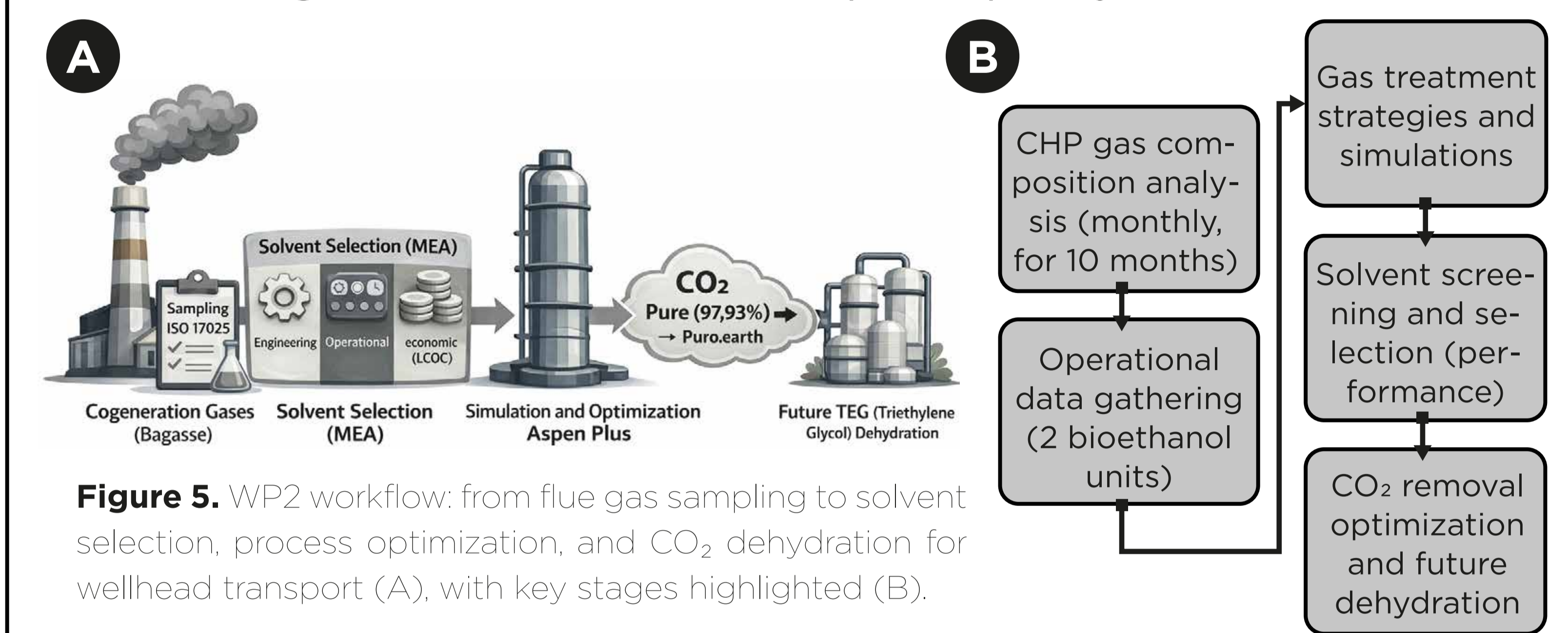


Figure 5. WP2 workflow: from flue gas sampling to solvent selection, process optimization, and CO<sub>2</sub> dehydration for overhead transport (A), with key stages highlighted (B).

The estimated average operating data for one of the investigated units are presented in Table 1, while Figure 6 shows the post-combustion carbon capture process flowchart.

Table 1. Average estimates of the operating conditions at the cogeneration outlet at one unit.

Description	Symbol	Estimate	Reference
CO <sub>2</sub> mass fraction (%)	yCO <sub>2</sub>	7.77	Monitoring Reports
O <sub>2</sub> mass fraction (%)	yO <sub>2</sub>	6.95	Monitoring Reports
N <sub>2</sub> mass fraction (%)	yN <sub>2</sub>	55.38	Monitoring Reports
H <sub>2</sub> O mass fraction (%)	yH <sub>2</sub> O	29.9	Monitoring Reports
CO concentration (ppm)	[CO]	53.44	Monitoring Reports
CO <sub>2</sub> mass flow rate (t/h)	mCO <sub>2</sub>	181.94	Publicly Reported
Total mass flow rate (t/h)	m <sub>t</sub>	2,340.06	Own Estimate
Operation time (h/year)	t <sub>op</sub>	7,200	Own Estimate
Outlet temperature (°C)	T	91.41	Monitoring Reports

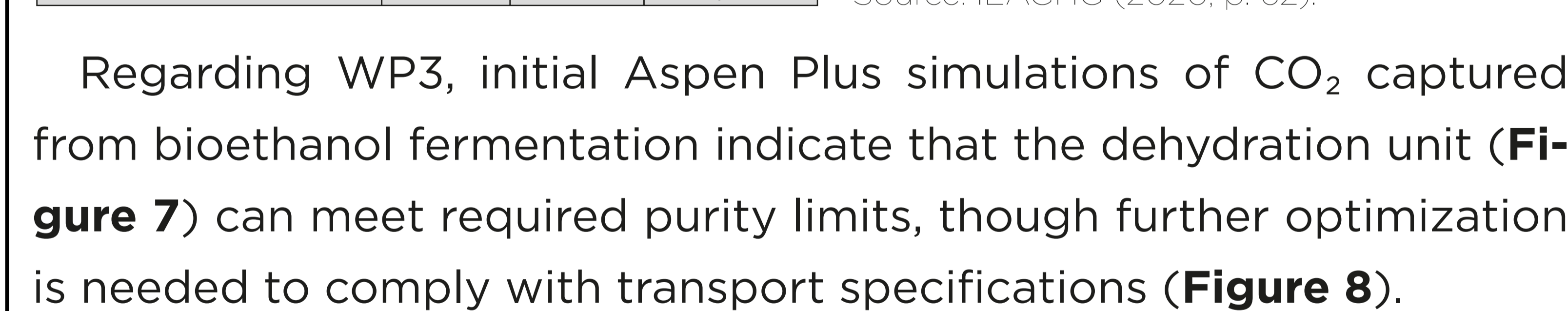


Figure 6. General scheme of the amine-based post-combustion CO<sub>2</sub> capture process. Source: IEAGHG (2020, p. 62).

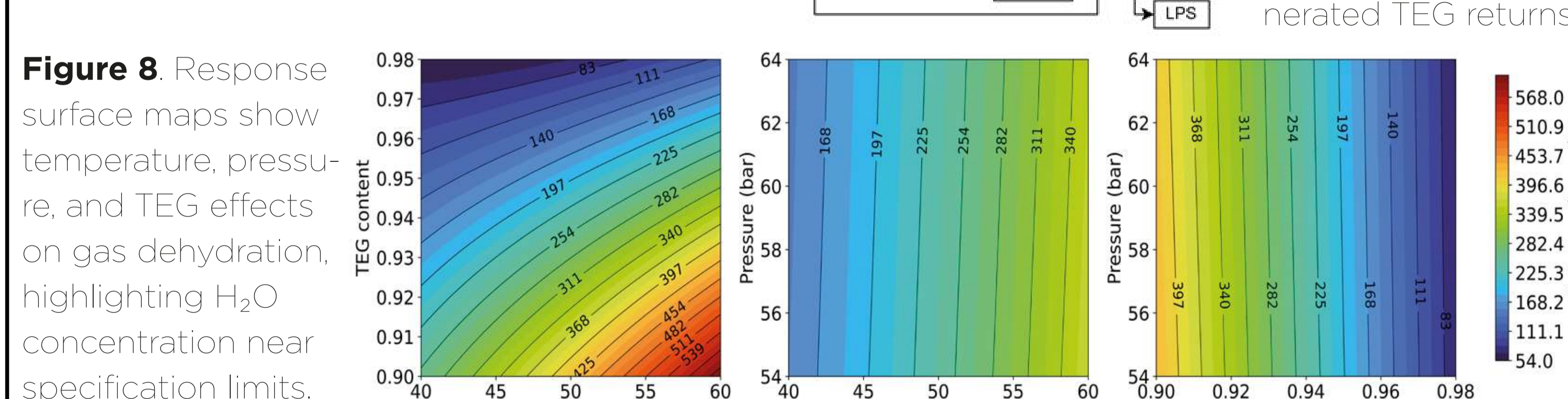
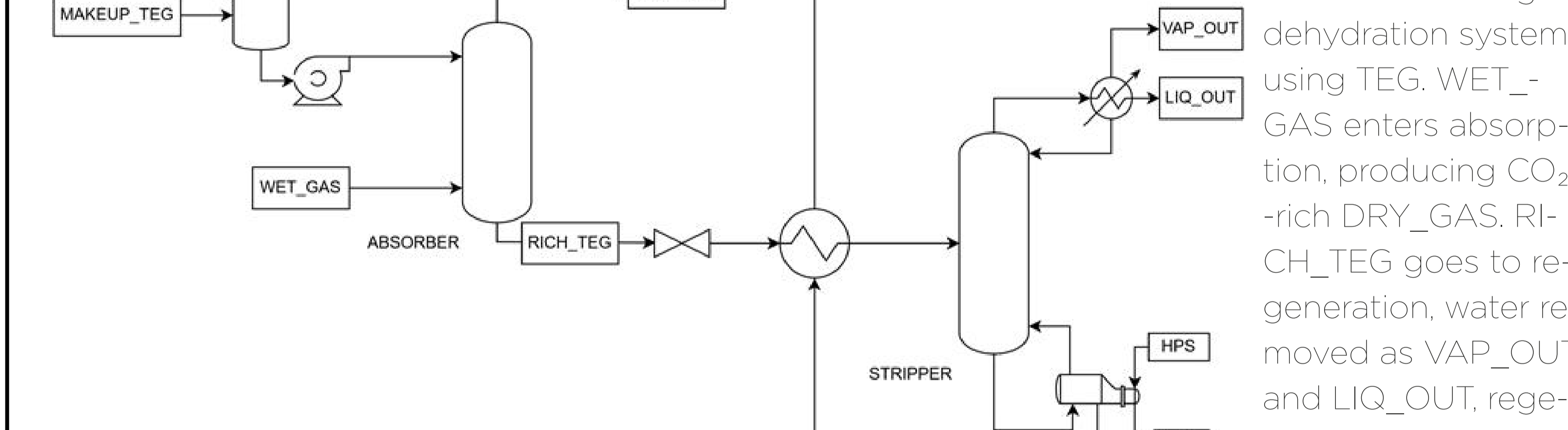


Figure 8. Response surface maps show temperature, pressure, and TEG effects on gas dehydration, highlighting H<sub>2</sub>O concentration near specification limits.

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### Results and Observations

#### Geological CO<sub>2</sub> Storage

Integrated activities will convert raw geological data into validated storage capacity, ensuring structural integrity and feasibility for CO<sub>2</sub> containment.

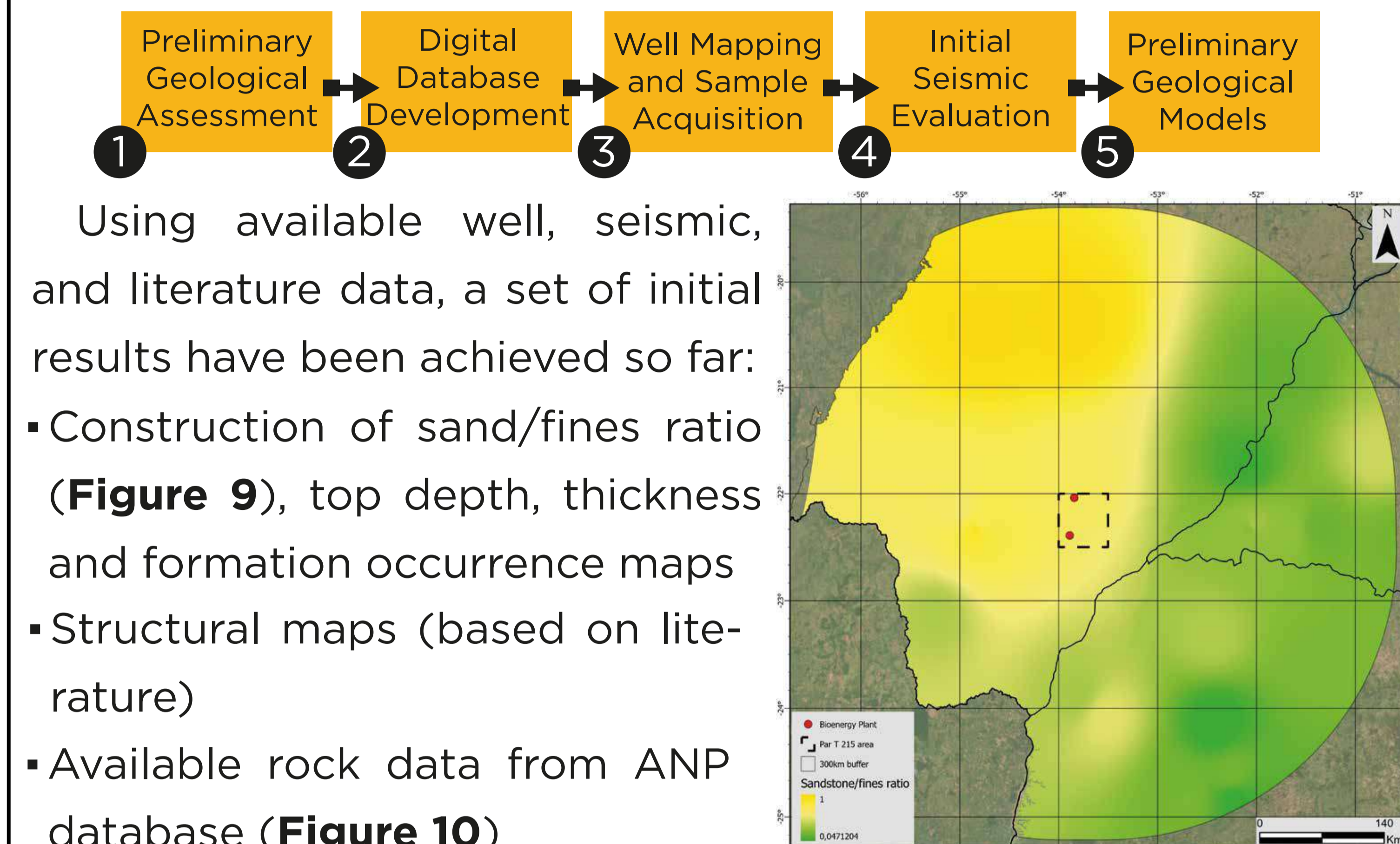


Figure 9. Sandstone/fines ratio map, showing the highest concentration of sandstones to the NW (Guatá Group).

Using available well, seismic, and literature data, a set of initial results have been achieved so far:

- Construction of sand/fines ratio (Figure 9), top depth, thickness and formation occurrence maps
- Structural maps (based on literature)
- Available rock data from ANP database (Figure 10)
- Salinity data from wells <200km radius (Figure 11)
- Application of seismic attributes and specialized workflows (Figure 12).

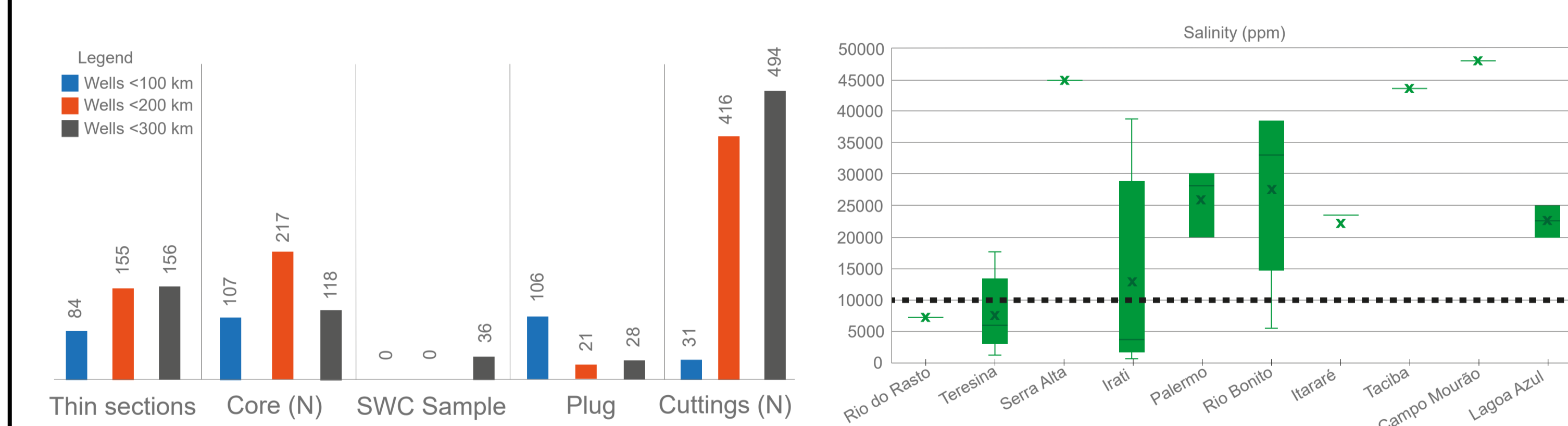


Figure 10. Rock data available upon request for access through the ANP (legal authority).

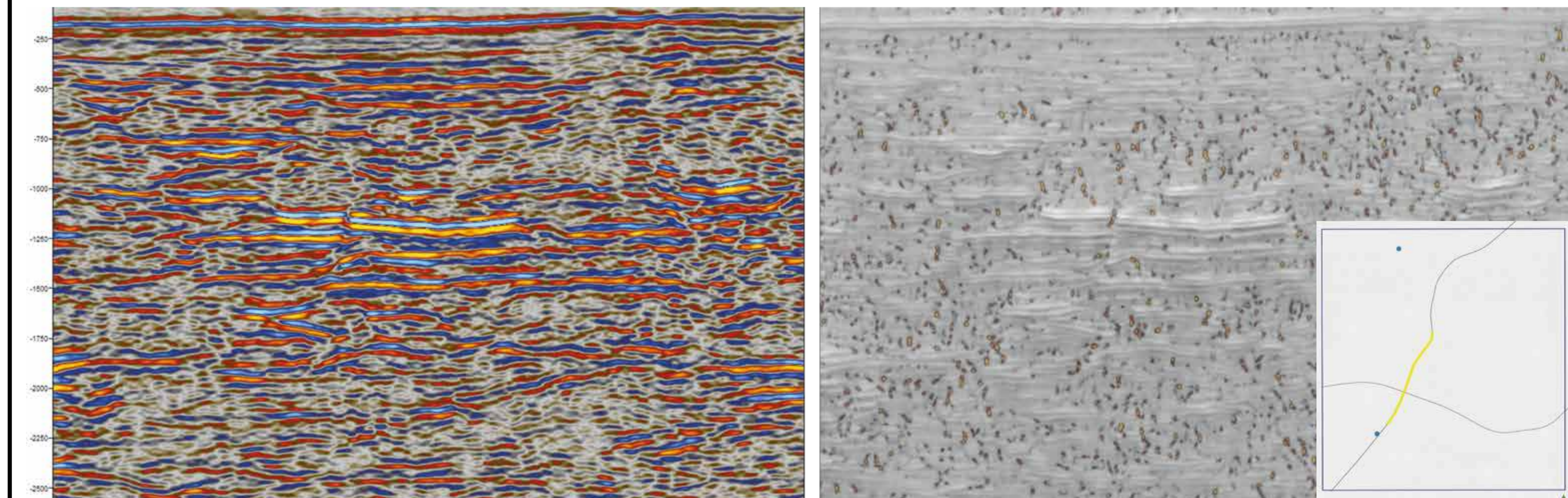


Figure 11. Salinities obtained from formation tests conducted in wells.

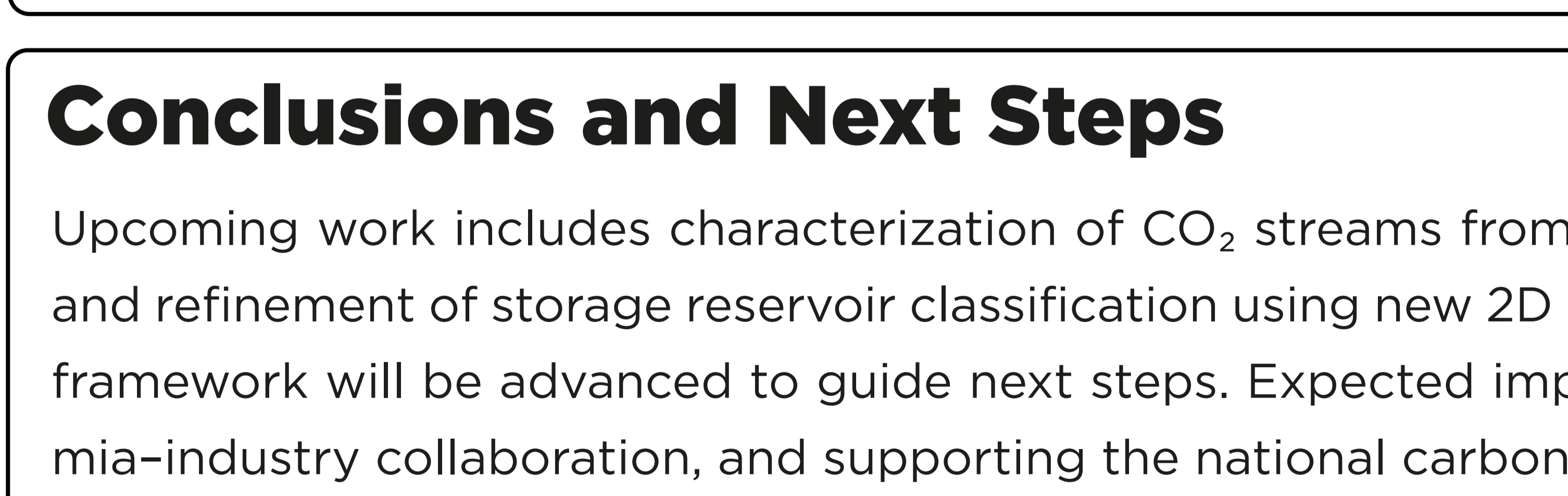


Figure 12. Seismic line interval (shown in yellow on the map), after applying the attributes Relative Acoustic Impedance (left) and Chaos combined with TecVA (right).

### Conclusions and Next Steps

Upcoming work includes characterization of CO<sub>2</sub> streams from fermentation and cogeneration, delineation of capture pathways, and refinement of storage reservoir classification using new 2D seismic data. The MMV strategy, risk assessment, and carbon credit framework will be advanced to guide next steps. Expected impacts are strengthening Brazil's BECCS readiness, fostering academia-industry collaboration, and supporting the national carbon neutrality agenda.

### Monitoring, Measurement and Verification (MMV)

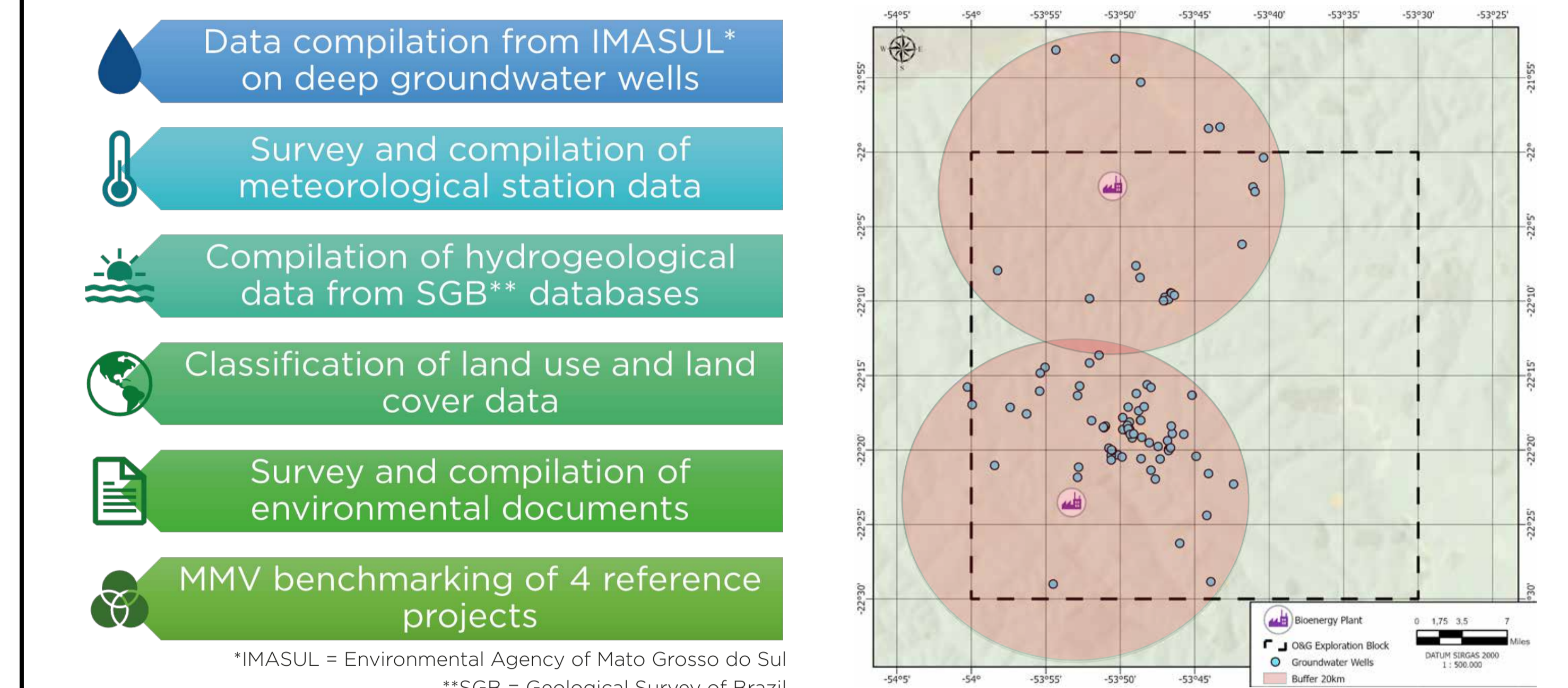


Figure 13. Location of groundwater wells within a 20 km radius of the bioenergy units.

Table 2. Benchmark projects being used as technical reference for MMV plans.

Project	Location	Injection Fm. and Depth
Archer Daniels Midland IL-CCS	Illinois, USA	Mount Simon Fm. (7.000 ft)
Bonanza Bioenergy	Kansas, USA	N/A
Red Trail Energy CCS (Gevu North Dakota)	North Dakota, USA	Broom Creek Fm. (6.380 ft)
Blue Flint Ethanol	North Dakota, USA	Broom Creek Fm. (4.710 ft)

Table 2. Benchmark projects being used as technical reference for MMV plans.

### Carbon Credits Project

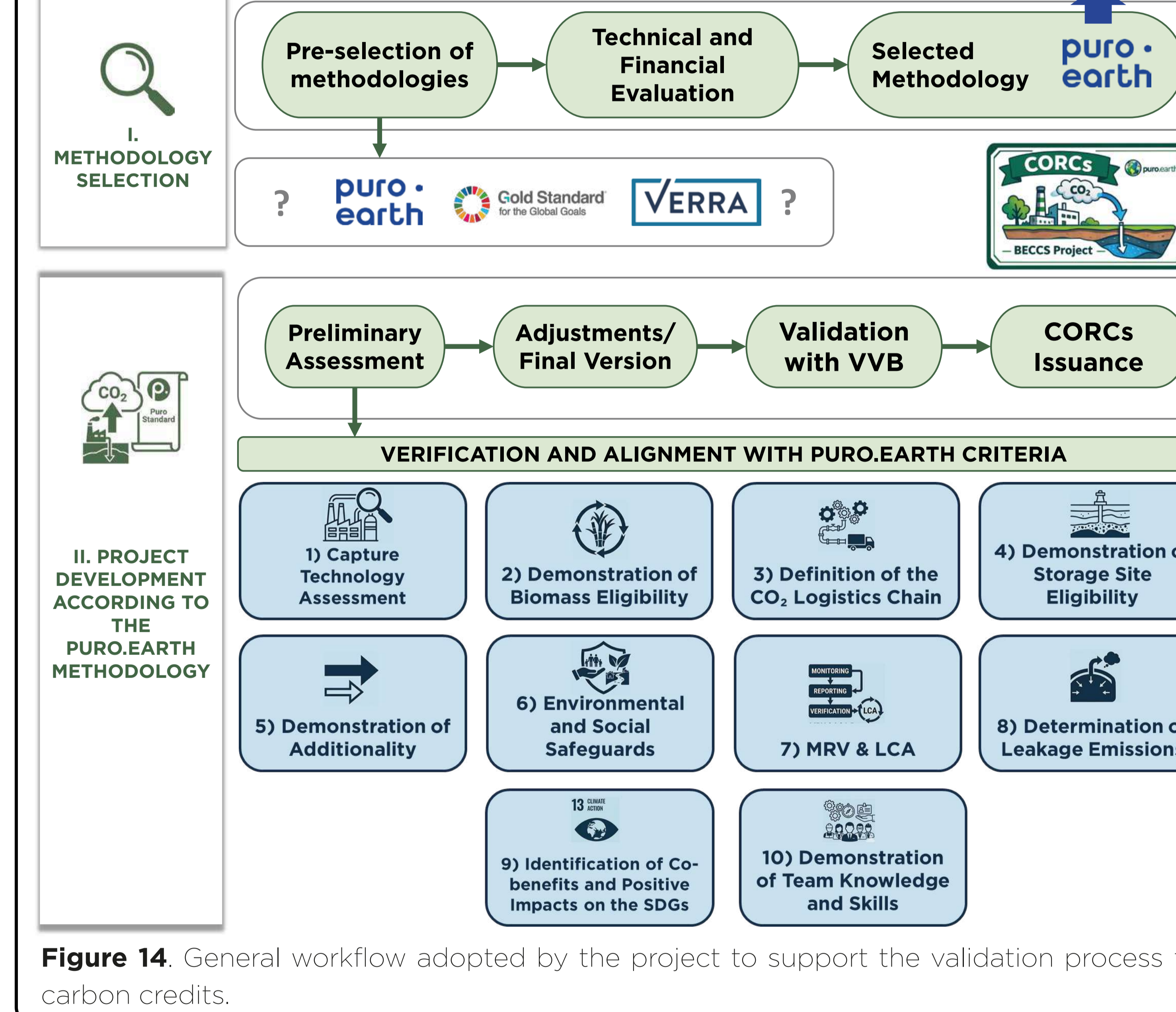


Figure 14. General workflow adopted by the project to support the validation process for carbon credits.

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