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Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
International Climate Initiative
Implemented by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
CLIMATE CHANGE CONSULTANTS

CARBON CAPTURE IN SOUTH AFRICA

An overview on Carbon Capture and Storage or Utilisation in South Africa

IMPRINT

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

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Bonn and Eschborn, Germany

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Layout:
peppermint werbung berlin gmbh, Berlin

The International PtX Hub is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Affairs and Climate Action (BMWK). Financed by the International Climate Initiative (Internationale Klimaschutzinitiative, IKI), the International PtX Hub is a contribution to the German National Hydrogen Strategy of 2020 and represents one of the four pillars of the BMUV's PtX action programme initiated in 2019.

For further related reading, we recommend:

- Sustainability Briefing #1: Carbon sources in the context of Power-to-X (https://ptx-hub.org/publication/sustainability-briefing-1-carbon-sources-in-the-context-of-ptx/)
- Carbon sources for the production of Power-to-X and synthetic fuels in South Africa (https://ptx-hub.org/publication/carbon-sources-for-the-production-of-ptx-and-synthetic-fuels-in-south-africa/)

Pretoria, March 2024

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Carbon | Capture | Storage | Utilisation

Carbon Capture and Usage (CCU) is a process that captures carbon dioxide (CO_2) emissions from various sources, such as industrial processes, and then converts or utilises the captured CO_2 into products thereby creating a revenue stream which can off-set the cost of the capture process. This approach aims to reduce greenhouse gas emissions while simultaneously creating economic value. Examples of CCU applications include using captured CO_2 to produce products such as sustainable aviation fuels and fertiliser (Power-to-X (PtX) products) and even building materials. To ensure maximum sustainability credentials, captured fossil-based carbon should be embedded into products with high longevity (such as cement or durable plastics) to ensure that the carbon is not released back into the atmosphere in the short-term.

Carbon Capture and Storage (CCS), on the other hand, is a process that captures CO_2 emissions e.g. from industrial processes or point sources and then stores the captured CO_2 underground in geological formations, preventing it from being released into the atmosphere.

Both CCU and CCS are considered important tools in the fight against climate change as they help reduce CO_2 emissions and can contribute to a carbon-neutral future. However, they have different objectives and end-uses, with CCU focusing on product creation and economic benefits (e.g. through the production of PtX products) while CCS centers on emissions reduction and long-term storage.

The terms CCU and CCS are gaining more momentum in recent discussions – firstly, with respect to sustainable carbon sourcing for PtX products and secondly, in regard of countries commitments of reaching net-zero emissions. Therefore, this brief intends to provide a general overview on CCU and CCS in South Africa to provide a basis for more aspect oriented technical discussions within these spheres.

CCS & CCU in South Africa: What happened so far?

Over the past two decades, CCS/CCU has intermittently garnered attention in South Africa. As early as 2004, South Africa embarked on a carbon capture programme, when it was identified that the country had capturable emissions and storage opportunities. At a workshop held during 2006, it was decided to focus on geological storage and an Atlas on Geological Storage of Carbon Dioxide in South Africa was published, followed by a detailed geological report. The Atlas indicated a theoretical geological storage capacity of 150 giga tonnes, of which ~98% was off shore, identifying four possible CO_2 geological storage basins (see map next page) [[1]]:

- Orange basin [offshore; off the west coast];
- Outeniqua basin [offshore; off the southern coastline and partly onshore and close to the only producing gas/ petroleum wells in South Africa];
- Durban/Zululand basin [east coast; onshore and offshore]; and
- Karoo onshore basin [near the main coal fields and main coal-based electricity generation and synfuel production centers].

Consequently, a South Africa Pilot Carbon Storage Project (PCSP) was launched, as a proof-of-concept, focusing on the onshore region of Zuzuland Basin (as a first, most cost-effective, approach compared to offshore sites). Since the launch of the original Atlas, the Council of Geoscience (CGS) has explored further possible geological storage sites, with the PCSP now to have been moved from the Kwa-Zulu Natal Province to the Mpulalanga Province – closer to the source of most point CO_2 emissions.

Recognising the potential opportunity of CCS in South Africa, the World Bank embarked on a US$ 1.35 million programme in 2009 to support capacity and knowledge building around CCS. The programme provided recommendations for the respective legislation/regulation framework and included public awareness and engagement actions. Specific challenges with respect to CCS in the South African context were identified, such as the large number of official languages, complex governance framework, diverse land ownership and environmentally protected areas in the region of the PCSP. Phase II of the Worldbank programme includes support of US$ 23 million, towards actual CSS demonstration: the project is set to be based around the town of Leandra, Mpumalanga province, where a pipeline will transport compressed CO_2 from major emitting sources, such as Sasol's Secunda, directly to the identified injection site that is overlain with an 'impermeable rock cap'. The project will test the feasibility of injecting between 10,000 to 50,000 metric tonnes of CO_2 (a year) to a depth of at least 1 km, with the first injection expected towards the end of 2025 [[2; 3]].

Overall, the current debate on CCS/CCU in South Africa has comparatively faded in recent years. The National Development Plan 2030 (published in 2012) mentions CCS as a potential route for cleaner coal-fired power stations, whereas CCS was put forward as one of South Africa's Flagship Programmes in the 2014 National Climate Change Response White Paper [[4]]. But there is no mention, nor targets, about carbon capture in the revised NDC 2021 (First Nationally Determined Contribution Under the Paris Agreement) [[5]]. And in the other key energy policy publication, the Integrated Resource Plan (IRP) 2023, there are no specific targets about CCS/CCU, but rather generic mentions of its potential, specifically in the context of coal power plants, and scope for partnerships, e.g. "*Given the significant investments required for the advancements of CCUS technology, South Africa must continuously pursue strategic partnerships with international organisations and countries that have made advancements in the development of cleaner coal technologies*" [[6]].

Geological storage of carbon dioxide in South Africa?

Possible deep saline formation storage opportunities onshore and offshore along the coast of South Africa and Mozambique and for the deep coalfields of the Karoo Basin

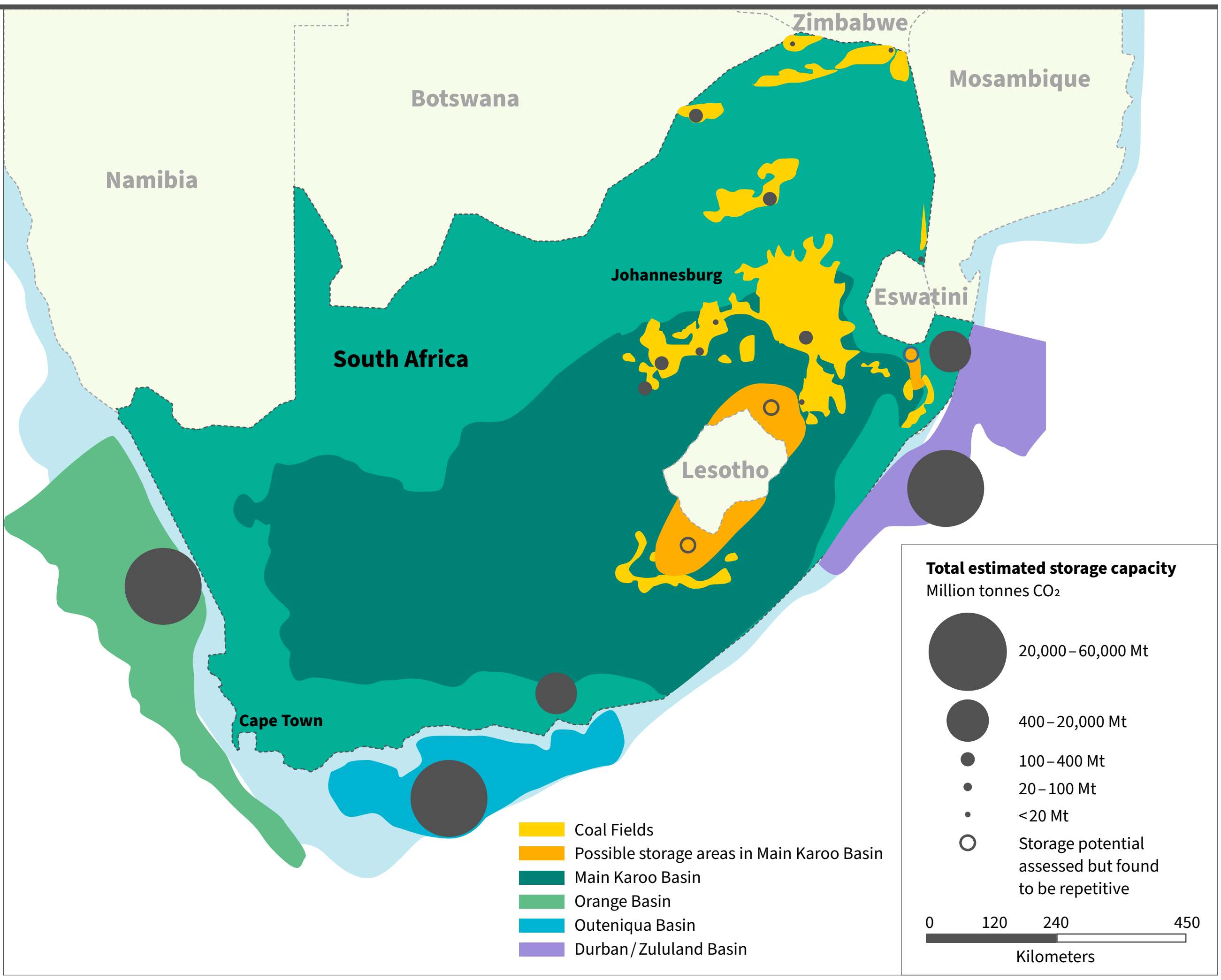

Figure: Derived from the Atlas on Geological Storage of Carbon Dioxide in South Africa, compiled by the Council for Geoscience, 2010

What is the status of CCS / CCU in South Africa today?

New CCU discussions and applications have emerged recently, mainly in the context of a Hydrogen economy and potential pathways for PtX, but there are no specific national plans, nor specific targets yet, regarding the utilization of CO_2. The National Business Institute (NBI) recently published a series of reports on the decarbonisation of South Africa's main industry sectors [7]. The reports explore several scenarios for CCS with the Durban basin as a potential CO_2 storage site, acknowledging the need for further research to confirm its suitability. These scenarios begin with capturing high-concentration process emissions from Secunda (Coal-to-Liquid), then expand to include Sasolburg (Gas-to-Chemical), and subsequently encompass the iron and steel and cement sectors, ultimately incorporating emissions from power generation. The study concludes that the Johannesburg industrial cluster, responsible for over 80% of the nation's emissions eligible for capture, offers the most cost-effective CCS value chain. For the power sector, last-mile decarbonisation scenarios are also proposed (using green hydrogen, CCUS, or DACCS pathways), with recognition that validation and decision-making should occur between 2030-2040 to target net zero by 2050, contingent on the maturity of these technologies.

Furthermore, there are no national policy documents, white papers, or decarbonisation reports in South Africa that currently investigate or contemplate the possibility of exporting CO_2.

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South Africas industry is currently taking some small first steps towards testing and incorporating CCUS within their processes. ArcelorMittal has established a two-fold partnership with Sasol with the intent to a) capture the carbon produced at its Vanderbijlpark Works and transport the gas via pipeline to Sasol's nearby processing and production facilities in Sasolburg; and b) produce greensteel via direct reduced iron (DRI) technology at the Saldanha Works, using green hydrogen produced by Sasol. ArcelorMittal has also singed an Memorandum of Understanding (MoU) with Equinor to develop value chains in CCS, focussing on logistics and including key issues around the costs of moving captured carbon sites for conversion and production [8].

Sasol, finally, apart from its partnership with CGS for the first carbon injection demonstration in Leandra (see above) is also exploring partnerships with Globeleq for sequestration of CO_2 from gas-fired power plants in Mozambique. In terms of the government supporting funding for CCUS activity and projects, as of 2012, CCS qualified as an eligible project activity under the UNFCCC's Clean Development Mechanism (CDM), provided that the project resulted in "real, measurable and long-term benefits related to the mitigation of climate change" [9].

Initially skeptical about the economic viability of carbon capture technology due to limited geological knowledge in the region, Sasol seems to adjust this position now. Recent investigations by the Council for Geoscience revealed a more significant potential for onshore carbon storage in the country. Sasol has now acknowledged the increased opportunities for Carbon Capture and Utilisation (CCUS) in South Africa and has signed an agreement with the Council for Geoscience to explore and develop CCUS initiatives, with the goal of capturing more than 85% of CO_2 emissions from power plants and industrial pointsources. This shift aligns with South Africa's commitment to reduce greenhouse gas emissions, especially in key industrial facilities [10].

However, introduced in June 2019, followed years of planning, consultations, and legislative processes, South Africa introduced a carbon tax that is currently priced at 190 rand (approximately US$ 10) per tonne of carbon dioxide equivalent emissions above certain thresholds. The carbon tax legislation stipulates that the initially introduced rate undergoes annual increases calculated as Consumer Price Index (CPI) and will only be adjusted based on CPI. Consequently, for the 2023 calendar year, the carbon tax rate rose from R159 per tonne of carbon dioxide equivalent (CO2e) to R190 per tonne of CO2e [11].

The carbon tax applies to various sectors, including energy, industry, and transportation, with the aim of encouraging businesses to reduce their carbon emissions. Exemptions and tax relief measures have been implemented to alleviate the burden on industries and ensure competitiveness, which results that the effective rate of the tax substantially lower as it is based on actual revenue received. Consequently, in terms of incentives for industries to adopt CCS and CCU measures, there is still room for improvement [12].

What are the barriers for CCU or CCS in South Africa?

Despite the above public and private initiatives on Carbon Capture and Storage (CCS) and Carbon Capture and Utilisation (CCU), there remain a series of barriers preventing the prioritisation of these technologies as core mitigation strategies. These identified challenges encompass a diverse range of issues that collectively hamper the advancement of CCS/CCU within the South African context, and include [13]:

- **Lack of policy and regulatory clarity:** One significant hurdle is the absence of clear and consistent policies and regulations pertaining to CCS/CCU. The absence of a well-defined and stable regulatory framework creates uncertainty for potential investors and stakeholders. This uncertainty can deter financial commitments and slow down project development.
- **Inadequate understanding of technology effectiveness:** The effectiveness and feasibility of CCS/CCU technologies are not widely understood. Public and private stakeholders may be hesitant to embrace these solutions due to a lack of knowledge and information regarding their benefits, costs, and potential impact on emissions reduction.
- **Limited domestic eesearch and development:** The limited volume of domestic research and development activities related to CCS/CCU in South Africa is another challenge. A robust local research and development ecosystem is essential to drive innovation, optimise technology deployment, and tailor solutions to local conditions and needs.
- **Scarce skilled workforce for CCS development:** The development of CCS/CCU projects necessitates a skilled workforce with expertise in relevant areas such as geology, engineering, and environmental science. The current skills base in South Africa may not be adequately equipped to support the growth of these technologies.
- **Underdeveloped market and private sector engagement:** The market and private sector interest in CCS/CCU initiatives is not fully realised or articulated in South Africa. Attracting investment and fostering a thriving market for these technologies requires a concerted effort to engage the private sector, establish clear incentives, and create avenues for collaboration.

How can South Africa further enhance its efforts?

In the international context, and drawing from experience in countries where CCUS is more advanced, the respective legal and regulatory framework that South Africa could adopt is based on the following dimensions, as outlined in the **IEA CCUS Handbook** [[14]]:

- **Defining the regulatory scope:** issues that set the legal parameters for the classification and ownership of CO_2.
- **Environmental reviews and permitting:** requirements for operators to minimise environmental and public health impacts through detailed assessments and data collection and reporting.
- **Enabling first-mover projects:** approaches to reduce regulatory barriers and provide certainty to first- and early-mover projects.
- **Ensuring safe and secure storage:** issues that cover the full range of the storage development process, from resource assessment to the site closure process. This includes robust monitoring and reporting requirements for operators and financial security obligations, including any requirements to remediate the CO_2 storage site.
- **Addressing long-term storage liabilities:** issues surrounding requirements and responsibilities of operators and the relevant authority following the closure of a storage site.
- **International and transboundary issues:** regulatory issues that may arise from the cross-border transport and storage of CO_2.
- **Facilitating CCUS hubs:** considerations for enabling shared CO_2 transport and storage infrastructure.

What else happens internationally?

Regarding the overall **discussions and negotiations** on **CCUS in the international arena**, these are broadly shaped by the following main initiatives:

- **The Paris Agreement:** Adopted in 2015, under the United Nations Framework Convention on Climate Change (UNFCCC), the Agreement recognised CCUS as one of the technologies that could contribute to limiting global warming to well below 2 degrees Celsius above pre-industrial levels. Many countries included CCUS in their national climate action plans (NDCs) submitted as part of the Paris Agreement.
- **COP26 and global Initiatives:** The 26th UN Climate Change Conference of the Parties (COP26), held in November 2021, featured discussions on CCUS. Various global initiatives and partnerships were launched to promote the development and deployment of CCUS technologies in the energy sector.
- **Net-zero goals:** Many countries, including major emitters, have set net-zero emissions targets for mid-century or earlier. Achieving these targets often requires the use of CCUS to offset emissions that are challenging to eliminate, especially in sectors like heavy industry and some aspects of the energy sector.

Finally, when it comes to research and development activity globally, after a rise in CCUS patents since 1996, 2014 was the start of a decline in the respective metric [[15]]. Nevertheless, significant research challenges remain, falling into the following broad themes [[16]]:

- **Capture:** drive down the cost and enhance performance of capture technologies for different emission sources.
- **Storage & transportation:** characterise and develop safe, permanent subsurface CO_2 storage, and technologies that support safe and efficient transportation of CO_2 and storage opportunities.
- **Utilisation:** expand the strategic uses of CO_2 and support the development of cost and energy efficient utilisation pathways which result in long term storage of fossil-based carbon should be prioritised.

REFERENCES

1 Atlas on Geological Storage of Carbon Dioxide in South Africa, compiled by the Council for Geoscience, 2010, ISBN 978-1-920226-24-4 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3820378

2 South Africa aims to bring pilot carbon capture project online in 2023 | Reuters

3 Sasol Climate Change Report, for the year ended 30 June 2022.

4 https://www.gov.za/sites/default/files/gcis_document/201409/nationalclimatechangeresponsewhitepaper0.pdf

5 https://unfccc.int/sites/default/files/NDC/2022-06/South%20Africa%20updated%20first%20NDC%20September%202021.pdf

6 https://www.energy.gov.za/IRP/2023/IRP%20Government%20Gazzette%202023.pdf

7 https://www.nbi.org.za/reports/

8 ArcelorMittal Decarbonisation Roadmap, South Africa, January 2023

9 https://law.uct.ac.za/sites/default/files/content_migration/law_uct_ac_za/1863/files/CCS_Report.pdf

10 https://www.news24.com/news24/tech-and-trends/news/sasol-makes-u-turn-on-carbon-capture-technology-20231025

11 https://www.gov.za/news/speeches/minister-enoch-godongwana-2024-budget-speech-21-feb-2024#:~:text=On%20environmental%20taxes%2C%20the%20carbon,effective%20from%203%20April%202024.

12 https://www.elibrary.imf.org/view/journals/002/2023/195/article-A003-en.xml#:~:text=The%20official%20carbon%20tax%20rate,about%20%248)%20by%20end%202022.

13 South Africa's 4th Biennial Update Report to the United Nations Framework Convention on Climate Change, Department of Forestry, Fisheries and the Environment, April 2021.

14 https://www.iea.org/reports/legal-and-regulatory-frameworks-for-ccus

15 Carbon Capture Utilization and Storage, Towards Net-Zero 2021, Kearney | Energy Transition Institute.

16 Adapted from the Government of Canada Energy Innovation Program – Carbon capture, utilization and storage RD&D Call

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