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Carbon Capture and Storage in the global climate debate

This policy brief refers mainly to the German Environment Agency's position paper on CCS in the national context and provides further thoughts on the international perspective.
https://www.umweltbundesamt.de/publikationen/carbon-capture-storage-diskussionsbeitrag

1 Indispensable but no panacea

Expectations about the role of Carbon Capture and Storage (CCS) in meeting the global temperature target of 1.5 °C are high. CCS is regarded as a component to achieve negative emissions for greenhouse gas neutrality mid-century, when emissions that cannot be avoided (residual emissions) need compensation in a range estimated between 4.8 to a maximum of 10 Gigatons annually (The State of CDR 2023; IPCC, 2023). Moreover, also for a reversal of a possible overshoot of 1.5 °C, climate scenarios refer to removing carbon from the atmosphere in combination with CCS. Reliance on CCS and its deployment on a large scale, however, comes with enormous challenges both nationally and internationally. The German Environment Agency therefore proposes to take a cooperative approach in international climate talks to inform about the role, uncertainties and risks, and to develop a common approach on how CCS should be negotiated and regulated to support, not undermine the toolbox addressing climate change.

First and foremost, a common understanding about the distinction between negative emissions (i.e. carbon dioxide removal, CDR) and fossil CCS is needed. "Fossil CCS" (The State of CDR, 2023) means CO_2 is captured from the exhaust stream of an industrial process burning fossil resources. Though a large part of those emissions could be kept from their ultimate release into the atmosphere, a significant fraction of CO_2 cannot be captured. Moreover, CCS increases the energy consumption due to additional energy demand for capture, transport and storage (IPCC AR6, 2005).. Thus, fossil CCS does not eliminate, but adds to the actual amount of CO_2 in the atmosphere On the contrary, CCS technology can contribute to achieve negative emissions if applied with procedures that remove CO_2 from the atmosphere . There are technical and natural options, namely Direct Air Capture combined permanent storage (DACCS) and the CO_2 uptake in plants in combination with combustion of bioenergy and permanent storage (BECCS).

The prevailing misconception between the role of fossil CCS and negative emissions for achieving the global climate target has to be overcome as fast as possible. Otherwise, in the public discourse true defossilization of industrial processes would lose support, which in turn would add to a lock-in effect of carbon-intensive infrastructure. Fossil CCS, in part strongly driven by economic interests of the coal, gas and oil industry, tend to push aside the viable mitigation options in international climate talks, which include renewable energies, demand-side reductions and nature-based solutions. Moreover, fossil CCS adds to the extraction of fossil fuels for it has been mostly used for enhanced oil recovery (EOR) up to date. Except for EOR, the CCS technology currently is not economically viable (CIEL, 2021).

Next to the financial risks, relying on CCS at this point in time faces technical issues and uncertainty about transport and storage volumes. In 2023, the actual global capture capacity was about 49 million tons (0.049 Gt) per year (Global CCS Institute, 2023). That corresponds to a mere 0.1% of the global annual emissions from the energy sector alone, pointing to a large gap between low operational capacity and the assumptions made in some climate policy scenarios.

The latest IEA's net zero roadmap, for instance, relies on a capacity of 6000 million tons (6 Gt) per year in 2050, noting that the role of CCS has already been downgraded to correct for overconfidence (IEA, 2023). These still probably unattainable CCS rates demonstrate the need to minimize as much as possible the amount of residual emissions that have to be compensated for. The vast majority of emissions (37 Gt in 2022) need to be reduced drastically to make mid-century greenhouse gas neutrality possible (IEA 2023). But due to the urgency to reach global climate goals, a massive reliance on the development of CCS technology will remain on the political agenda.

In light of the overall picture, we suggest that the limited potential of storage facilities and resources should be reserved exclusively for absolutely unavoidable emissions, explicitly excluding fossil emissions. Especially because CCS will become indispensable as a part of negative emission technologies, climate talks should focus on this role of CCS alone, and foster cooperation on the requirements for transport, storage safety and monitoring. In order to establish a test case that serves this purpose, CCS for thermal waste treating plants seems to be a feasible and relevant pilot scheme. Waste+CCS (WACCS) would sequester emissions that are hard to abate at the end of a long value chain with the potential to achieve negative emissions in the future. Noting that not all countries operate these plants to the same extent, we would like to encourage dialogue and joint discussion of specific strategies for testing such CCS-pilot projects, addressing the following challenges and risks.

2 Addressing concerns and responsibility

2.1 Need for separate targets and prioritization

Since CCS should not minimize the efforts in mitigation it is important to have separate targets in the Nationally Determined Contributions (NDCs) and Long-term strategies (LTSs) with a clear prioritization of emission reductions followed by emission removal (WRI, 2023). A further distinction within the category of negative emissions between natural and technical sinks is recommended. A focus on natural sinks (e.g. ecosystem restoration) strengthens the synergies for society and biodiversity while technical sinks (e.g. DACCS) should be defined as second best options only. Fossil CCS could be listed as an additional effort in case that certain negative emission goals are achieved. A common understanding of the terminologies fosters fair contributions, transparency and trust. This includes the definition of residual/unavoidable/hard-to-abate emissions and the sufficiency of storage duration/permanence.

2.2 Limited storage capacity

Storage capacity has two dimensions. Theoretical physical storage capacity can include all suitable geological formations without including accessibility. Realistic (i.e. feasible) storage capacity is much lower and can only be quantified exactly after a site-specific investigation. The IPCC estimates technical storage capacity, but also states that actual numbers depend on the regional availability (IPCC AR6, 2023). The actual dimension is further limited by the feasible injection capacity (tons per year). The stability and therefore permanence of a storage site is higher with lower pressure, requiring a lower injection rate. Therefore, when comparing the total global storage capacity with the demand for global negative emissions, the timeframe has to be considered carefully as well. The observed injection rate from a flagship CCS facility not doing EOR is 1 Million tons (0.001 Gt) per year. Based on this pilot, thousands of new CCS plants of the same size would be required in the next decades, depending on the assumed net zero scenario). This illustrates the challenges in terms of meeting the demand for industrial construction capacity.

Uncertainty also stems from unknown permanence of CO2 storage. The injection itself does not guarantee that the carbon is safely stored. Technologies providing mineralization of CO2 after a few years are an option, yet consume huge amounts of water, leading to several further issues. The injection method with less water consumption takes tens of thousands of years until the carbon is mineralized, and, as different CCS projects demonstrate, disruptions are very likely to arise, whether during drilling or afterward due to seismic shifts (IEEFA, 2023). Thus, collecting state-of-the-art data on the diverse storage capacities across world regions, with an evaluation of reliable and non-reliable potential, needs further on-site research and platforms to exchange information.

2.3 Underestimated monitoring cost

Monitoring serves both the credibility of negative emissions as such as well as the safety of CCS. A thorough monitoring over centuries would be necessary for the protection of human health, ground water and ecosystems against risks from continuous small leakages as well as from sudden blow-outs. Moreover, the extent of these risks (is not fully understood. A common understanding of the costs attached to sufficient monitoring is needed. These costs seem to be significantly underestimated with respect to the permanent search for leakages, observation of the seismic activity during and after injection into the ground, and not least a thorough geological site examination before the facility is build. Seismic subsurface surveys demand highly specialized technologies and staff (IEEFA, 2023).

2.4 Transport infrastructure

A scale-up of CCS will come with high demands on infrastructure for the transport from the facility where the CO_2 is captured to a storage site. This aspect needs to be part of the public debate and understanding for global cooperation. Thousands of kilometers of new pipelines would have to be build each year, combined with increased ship, train and truck transport (Global CCS Institute, 2022). Besides the costs and resources for this, the expenditure and costs of monitoring of this infrastructure has to be considered as well because the transport through pipelines comes with risks for nearby environment and settlements (CIEL, 2021).

2.5 Long term liability

Governments have to regulate private liability for CCS injections, including the need of precautionary funds for contingencies. The liability of a company for its CCS injection is ending after 15, 30 or 50 years in Australia, the EU and the USA, respectively (IEEFA, 2023). Leakages occurring afterwards are a public financial risk. Especially future generations will be confronted with managing storage safety and the burden of follow-up costs.

Given to the long-term storage requirement, geological shifts need to be anticipated. Reservoirs may expand over time, leading to unnoticed CO_2 diffusion underground and subsequently overstepping territorial boundaries. Hence, a number of complex regulatory questions must be resolved before CCS deployment, e.g. what will happen if a leakage is detected decades after the company's liability ends in the territory of a neighboring state.

2.6 Competing claims for using land and underground capacities

An underground storage site cannot be used for multiple purposes. This is due to geological formations, and the surface above and around it. The competition for different usages of land and surfaces for other technologies like offshore windfarms, deep geothermal energy or hydrogen storage requires to choose the most effective and sustainable use. Therefore, not only today's circumstances for protecting the climate have to be considered, but also demands of future generations.

3 International cooperation is key

Concerns and priorities around CCS and its role in international climate action need to be addressed in a comprehensive, inclusive and transparent manner. The challenges around CCS deployment must be taken very seriously and respective solutions have to be found to prevent the global community from falling into overreliance on CCS technology. To find sustainable and fair solutions, international cooperation is essential from a number of perspectives, including intra- and intergenerational fairness.

First of all, negotiators and civil society actors need to establish common ground on the role of CCS in achieving greenhouse gas neutrality. This includes a clear distinction between undesirable fossil CCS and CCS as technology to achieve negative emissions. Prioritization of emission reductions, definition of hard to abate emissions, and the potential demand for permanent CO2 storage need to be addressed. In this process, NDCs will have to take up prioritization of emission reduction, displayed in separate targets for reductions and removals.

Beyond a uniform use of terminology, intergovernmental trust and public acceptance have to be established by transparency at all steps from first considerations to final decisions, as well as for realistic cost estimates, implementation and monitoring of a facility. One step in this direction would be an international clearing house mechanism for information exchange such as the mechanism established under CBD Decision XI/20 Paragraph 15 and 9).

Sharing knowledge and resources is important to reduce risks and costs. States in which companies already run fossil CCS facilities are invited to share their experience, including not only success stories but also throwbacks and failures. This would enable mutual learning so that actors aiming at negative emissions can avoid these risks and can benefit from a best practice procedure. Moreover, it would help to estimate the role of CCS and identify trade-offs between mitigation and removal in net zero pathways more realistically and to focus on the most efficient tools to address climate change.

Cooperation on these matters can help to establish international minimum requirements and common standards for monitoring, enabling transboundary transport safety and permanent storage. Private standard setting bodies cannot take the lead in these crucial questions. To serve the purpose of protecting human health and ecosystems, these requirements and standards should be developed and negotiated by state representatives in transparent and legitimate processes.

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