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"Carbon Management": Opportunities and risks for ambitious climate policy

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Climate policy in the European Union (EU) and Germany changed significantly with the adoption of net-zero emissions targets. A key new development is the growing importance of *carbon management*. The umbrella term includes not only the capture and storage of CO2 (carbon capture and storage, CCS), but also CO2 capture and utilisation (carbon capture and utilisation, CCU) as well as the removal of CO2 from the atmosphere (carbon dioxide removal, CDR). It is important to provide clarity when differentiating between these approaches and identifying their relation to so-called residual emissions and hard-to-abate emissions. This is particularly important because it will determine the overall ambition of climate policy as well as shape future policy designs and their distributional impacts. Current policy and legislative processes should ensure that carbon management does not delay the phase-out of fossil fuels. New policy initiatives present an opportunity to actively shape the interface between ambitious climate and industrial policy.

With the net-zero emissions targets, which are to be reached in Germany in 2045 and at the EU level in 2050, a new challenge has emerged alongside the need to achieve conventional emission reductions: Increasingly, the question centres on how to deal with emissions that are considered *hard-to-abate*. As the target years of the European and German climate laws draw closer, more attention is being given to those sectors in which a conversion to renewable energy sources alone will not be sufficient to reduce emissions to absolute zero. In addition to agriculture and waste incineration, the process emissions from cement and lime production are cited as examples here.

Carbon management has moved into the focus of political decision-makers in this context. Although specific legislation is still in its infancy, processes for strategy development have been initiated at both the European and German levels, setting the stage for future regulation. At the European level, new initiatives being led by the European Commission in the aftermath of the Fit for 55 reforms — such as the *Net Zero Industry Act*, the certification of CO_2 removals and the discussions about the 2040 climate target — are evidence of the growing momentum around the topic of carbon management. In Germany, it is above all the announced amendment of the German

Climate Change Act and the development of strategies for carbon management and dealing with unavoidable residual emissions that illustrate the new level of commitment to this issue.

Conceptual clarity: Dare to differentiate

So far, terms have been used very differently in the context of carbon management. However, clear definitions are an important starting point for future regulation. Carbon management usually includes the following three types of process chains: carbon capture, transport and storage (CCS), carbon capture, transport and subsequent utilisation (CCU) and CO_2 removal from the atmosphere (CDR).

Umbrella terms such as carbon management that emphasise commonalities are politically attractive. They allow complex technologies to be clearly communicated. In this specific case, the term also serves to integrate CCS, which has long been controversial, particularly in Germany, into a new narrative. In addition, it offers the possibility of delaying conflicts between political and industrial actors with different priorities regarding CCS, CCU or CDR for the time being. In order to identify the opportunities and risks of carbon management for ambitious climate policy, however, a differentiation must be made between its three components and their respective strategic roles in climate policy.

Underground storage: CCS

CCS comprises process chains in which CO_2 is captured and compressed for subsequent transport and underground storage. CCS can be used in different ways: in combination with fossil fuels (e.g. natural gas power plants and the production of blue hydrogen), to largely capture industrial process emissions (e.g. emissions in cement and lime production that are produced independent of energy supply), or to remove CO_2 from the atmosphere by capturing biogenic CO_2 (e.g. bioenergy plus CCS, BECCS) or from the ambient air (direct air capture plus CCS, DACCS). The strategic role of CCS in climate policy depends crucially on the type of CO_2 source. Central criteria are also the capture rates achieved and other emissions released in the respective process chain. The degree of maturity of the individual CCS processes varies greatly, and the costs also diverge significantly, depending on the application. Presently, a range of 50 to 150 euros per tonne is usually given for the cost of point source capture, transport, storage and subsequent monitoring.

The current debate often fails to explicitly distinguish between different CO_2 sources and applications. Whether and for which processes CCS will be considered is a largely unresolved political question, both in the EU and in Germany. Especially in Germany, the use of CCS in the context of fossil power generation is politically highly controversial. The debate about equipping coal-fired power plants with CCS led to a considerable polarisation of the issue in the late 2000s. In other EU member states, for example Poland and Hungary, this option has been discussed more openly. Outside Europe, the combination of fossil infrastructures with CCS is an integral part of the debate; for example, in China and India — countries with much younger coal-fired power plants — retrofitting CCS technology is being discussed as an option to minimise the risk of *stranded assets* as a result of ambitious climate policies.

Both EU-wide and German modelling assumes there will be low levels of CCS deployment in combination with different CO_2 sources until 2030. However, 550 million tonnes (Mt) of CO_2 captured via CCS are expected to be reached in the EU annually by 2050, and 34—73 Mt in Germany by 2045. To what extent and for which applications CCS will be considered a legitimate component of climate policy in Germany and Europe is likely to become one of the contentious debates at the interface of climate and industrial policy. In addition to the costly storage infrastructures — which will initially be developed primarily in north-western Europe because of the large storage potential — the connection to CO_2 transport infrastructures will also play an important role. Not all potential CCS users are located in large industrial clusters (e.g. lime and cement plants in Germany); the financial and infrastructural costs of transporting CO_2 by pipeline, ship or truck would be significantly higher for these users.

Carbon as a resource

Secondly, the term carbon management encompasses the capture, transport and subsequent utilisation of carbon (*carbon capture and utilisation*, CCU). During this process, in contrast to CCS, CO_2 is not stored in geological formations, but instead utilised in products. The role of CCU in climate policy depends not only on the origin of the CO_2, but also to a large extent on the lifetime of the resulting product and carbon balance of the process chain. On the one hand, CO_2 can be used directly as a material resource, for example in food, beverages and solvents. On the other hand, CO_2 can be chemically or biologically converted and used in the production of chemicals, synthetic fuels, building materials and fertilisers, among other things.

There are major challenges with CCU in terms of emissions measurement, reporting and verification (MRV) — in particular with regard to the permanence of storage, there are problems with accounting, depending on the type of product and its life cycle. For most CCU process chains, using CO_2 in products is simply a matter of delaying emissions. This delay can range from days and weeks (e.g. synthetic fuels) to several decades (e.g. building materials such as carbon fibre and wood). The topic of CCU is primarily being pushed politically by the chemical industry, which will still need CO_2 as a feedstock in and after the net-zero year. If CO_2 were to be used from decentralised point sources, such as cement and lime production and waste incineration plants, investments would have to be made in CO_2 transport infrastructures. Even if the existing natural gas network were largely repurposed for CO_2 transport, new pipeline construction projects would still be necessary.

Removing CO_2 from the atmosphere

Thirdly, the term carbon management also includes methods of CO_2 removal (*carbon dioxide removal*, CDR). In contrast to those CCS and CCU process chains based on CO_2 from fossil sources, CDR process chains have net-negative emission balances. This is achieved because the CO_2 either originates from biogenic sources or is removed from ambient air. The CO_2 can then be durably stored in geological, terrestrial, or ocean reservoirs, or in products. CCU and CCS can thus be part of CDR process chains.

It is evident that the use of CDR methods will be necessary in the medium term to achieve net-zero targets. The scenarios assessed by the Intergovernmental Panel on Climate Change (IPCC) indicate a need for net-negative CO_2 emissions in the second half of the century to meet the Paris Agreement temperature target. Many climate policy strategy documents at the EU and German levels show that on the way to net-zero greenhouse gas emissions, both CO_2 removals in the land use, land use change and forestry (LULUCF) sectors and CCS-based removal methods such as BECCS and DACCS are expected to be used. Marine removal methods have also received increased attention recently (SWP Comment 12/2023). In policy debates, usually only CCS-based CDR methods are subsumed under the collective term carbon management; LULUCF-based CDR methods are referred to as “carbon farming” at the EU level, and as part of “natural climate protection” in Germany.

LULUCF-based removal methods are already a component of climate policy. The EU Climate Law already allows for 225 Mt of net CO_2 removals from the LULUCF sector to contribute towards meeting the 55 per cent emissions reduction target by 2030. CCS-based removal methods (e.g. BECCS, DACCS), on the other hand, have not yet been integrated into German or European climate policy. During the development of the Fit for 55 package, a discussion of these approaches was largely avoided. It is evident from all major modelling studies on achieving greenhouse gas neutrality that the integration of CCS-based CDR methods is one of the upcoming climate policy tasks, and in recent months this has been clearly stated by decision-makers in Brussels as well as by the German government (SWP Comment 40/2022).

The key political challenge now is to clarify the role of CO_2 removal in climate policy. Critical voices from civil society and science fear that the expansion of removal capacities could lead to offsetting fossil emissions. Proponents, on the other hand, point to the need to counterbalance the expected residual emissions, which are unavoidable or can only be avoided at a very high cost, and see a danger of not being able to achieve net-zero targets if sufficient CO_2 removal capacities are not scaled up.

The contentious issue of residual emissions

With the operationalisation of net-zero targets into tangible policy measures, so-called *residual emissions* are becoming a major topic, both in climate policy and research. The term now frequently appears in position papers published by relevant stakeholders. It has also found its way into the German coalition agreement — the government programme agreed by the ruling parties (Social Democratic Party, The Greens, Free Democratic Party) when they formed a government at the end of 2021 — and the EU legislative process. Yet, it often remains unclear how individual actors define key terms (including residual emissions, process emissions, and hard-to-abate or unavoidable emissions). So far, neither uniform usage nor shared definitions have been established.

This is particularly problematic because the definition and expected volumes of residual emissions have significant implications for climate policy ambition, policy designs and distributional effects between economic sectors. To prevent ambiguities in policy debates, in ongoing strategy development processes and in future regulatory initiatives, we propose the following conceptual distinction (see Figure 1).

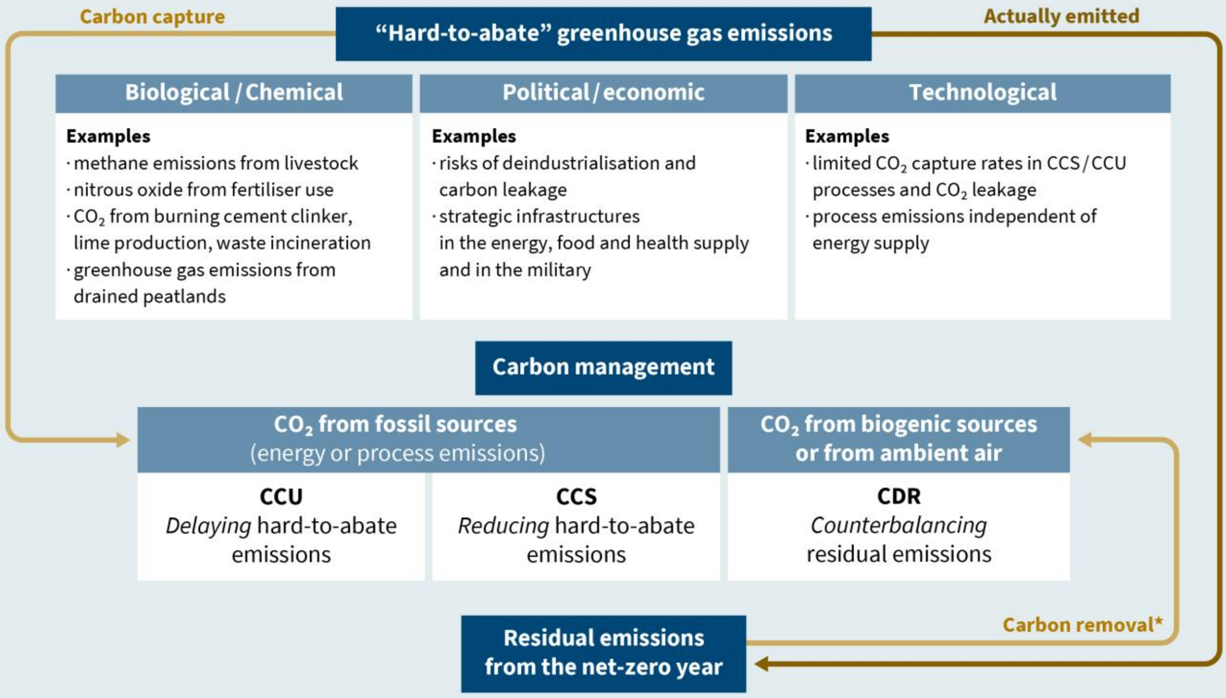
We define *residual emissions* as a quantity that simply describes which emissions actually enter the atmosphere in and after the net-zero year. We distinguish them from emissions that are considered *hard-to-abate*. Different actors, each with their own motives and justifications, are currently classifying certain types of emissions as hard-to-abate. The reasons are manifold. In political debates, the following three justifications are being combined in a variety of ways: firstly, the biological or chemical characteristics of certain processes (e.g. methane emissions from livestock or CO_2 emissions from clinker burning in the cement industry); secondly, emissions that are politically and economically difficult to abate (e.g. in connection with the risks of deindustrialisation and *carbon leakage)* or strategic infrastructures in the energy, food and health sectors as well as in the military; thirdly, technical constraints and insufficient technological progress (e.g. emissions from long-haul aviation and shipping or limited CO_2 capture rates when using CCS and CCU).

The analytical distinction between residual emissions and those that are characterised as hard-to-abate provides an important clarification. By drawing upon this differentiation, the policy challenges posed by residual emissions in and after the net-zero year and the political battles over hard-to-abate emissions can be addressed separately.

Furthermore, highlighting the various justifications indicates that emissions considered comparatively easy to avoid in climate-economic models or other techno-economic analyses may well be hard-to-abate for political reasons, due to path-dependencies and the relative importance of individual economic sectors. Finally, the distinction between residual and hard-to-

Figure 1

Greenhouse gas neutrality: Conceptual overview of key terms



* **Carbon removal:** CO_2 from ambient air or biogenic sources is absorbed / captured and stored. CCU or CCS approaches can be part of these net-negative process chains.

abate emissions makes it clear that the conflict over the latter is political in nature and cannot be settled by introducing an unambiguous definition. Conceptual clarity and clear differentiations are important, but they should not raise unfounded hopes that these conflicts will be resolved. The political disputes over what count as "legitimate" residual emissions in and beyond the net-zero year will intensify in the future.

Three roles for carbon management

In order to minimise ambiguities in the political debate and future regulation, it is also important to distinguish between the different strategic roles that carbon management can play in climate policy in relation to hard-to-abate and residual emissions. If, for the sake of reducing complexity, we leave aside the overlap of process chains that occurs in some applications, carbon management can play three roles in climate policy on the path to achieving net-zero emissions (see Figure 1).

CCS offers the possibility to *reduce* emissions that are hard-to-abate. For example, if CCS is used in cement and lime production — the most prominent examples of non-energy-related process emissions — CCS can be used to reduce the volume of emissions that are difficult to avoid. The use of carbon in CCU process chains, however, can — depending on the life cycle of the product — *delay* emissions into the *future* and, in addition to possible substitution effects, thus contribute towards achieving the net-zero target, at least temporarily. Emissions that are neither reduced by CCS nor delayed by CCU or occur in their process chains must be *counterbalanced* by carbon removals. Only this third role of carbon management makes it possible to meet a *net*-zero target. This underscores that the entire portfolio of carbon management approaches is an important building block for achieving climate targets. At the same time, it shows the importance of thinking about carbon management approaches in the context of their different climate policy roles.

The three roles — *reducing* and *delaying* hard-to-abate emissions as well as *counter-balancing* residual emissions — are each linked to different political and economic interests, actor alliances and regulatory challenges. If the connection between hard-to-abate greenhouse gas emissions, carbon management and residual emissions is not made explicit, carbon management initiatives will increasingly be criticised for exerting delay tactics that undermine ambitious climate action. The extent to which the individual approaches are used to achieve climate targets in the net-zero year and beyond will be largely determined by how successfully conventional emission reductions are implemented in the next 20 years. The scale at which carbon management is operational by then will depend primarily on how regulation and integration into existing climate policy instruments progresses and who — which EU member states, sectors, companies, etc. — invests in building the necessary capture, transport and storage capacities.

Opportunities and risks for ambitious climate protection

Both opportunities and risks arise for ambitious climate action in the context of the numerous ongoing processes for developing carbon management strategies and future legislative procedures.

The **opportunities** lie primarily in the fact that carbon management can establish itself as an important approach to shaping the interface between industrial and climate policy. Various, partly competing policy goals — such as emission reductions, environmental protection, the security of energy supply, economic growth and resilient supply chains — could be negotiated simultaneously. Carbon management policy could thus become an important platform to allow political tensions and emerging distributional conflicts to play out and facilitate the recognition of synergies. In a similar way, this also applies to the interface between agricultural and climate policy, which will become increasingly important and contested in the course of the debate on residual emissions (SWP Comment 40/2022).

Furthermore, actively addressing the carbon management issue could be the first step towards establishing new forms of international cooperation. In addition to technology development and the creation of new markets, an active carbon management policy also offers the EU and Germany the opportunity to shape benchmarks and standards — for example, through the certification of CO_2 removal methods or by establishing CO_2 injection capacity targets in the *Net-Zero Industry Act* at the EU level. Furthermore, multilateral negotiations — for example within the framework of Article 6 on international cooperation under the Paris Agreement, or the G7 and G20 formats — offer forums for increased cooperation. International cooperation is also a relevant dimension, as it enables exchanges on the different strategic roles for carbon management. In countries with large — and in some cases growing — coal-fired power plant fleets or high coal, gas or oil exports, CCS and CCU are discussed primarily as an option to secure fossil business models: a strategy that is often seen as undermining the climate goals of the Paris Agreement.

At the same time, all three elements of carbon management potentially carry the **risk** of “lock-ins” into fossil infrastructures (e.g. continued use of natural gas or blue hydrogen) and decreasing the level of pressure to move away from fossil fuels. Specifically, as CO_2 prices rise, climate policy is facing the challenge that businesses have incentives to implement CCS or CCU approaches rather than to pursue conventional emission reductions. A similar situation applies to CO_2 removal: The prospect of being able to counterbalance residual emissions in the future through CO_2 removal may lead to lower ambition to reduce emissions. The prioritisation of conventional emission reductions is repeatedly emphasised in relevant European and German strategy papers and is a core component of the political debate. However, how this prioritisation is to be reflected and codified in legislation in the long term is largely unclear.

At the same time, there is also the risk that carbon management approaches will not be scaled up quickly enough due to political restraint and a lack of political or institutional feasibility. However, according to current knowledge, without the development of appropriate carbon management capacities, net-zero targets will not be achievable, even with ambitious conventional emission reductions. Global and European evaluations point to a large gap between the CCS capacities achieved to date and the necessary future growth rates. A similar picture emerges with regard to carbon removal. Although removals are already being achieved in the forestry sector, neither the regulatory prerequisites nor the support for innovation for scaling up CDR capacities exist yet.

If these two risks — weakened ambitions in conventional emission reductions and overly optimistic hopes for scaling up carbon management — were to manifest, they would have the potential to significantly endanger the achievement of climate targets.

Next steps in carbon management policy

With clear distinctions between terminology and clarification of the respective climate policy roles played by the individual approaches, carbon management initiatives can enable a discussion about how much emissions must be reduced in the net-zero year and what capture, storage, utilisation and removal capacities will be needed by then. This politically uncomfortable debate should be pursued at both the German and European levels. The more residual emissions there are in and after the net-zero year, the more removal capacities will be needed and the more difficult it will be to meet the net-negative emissions targets already enshrined in German and European Climate Law.

Firstly, the ongoing strategy development and positioning processes in Berlin and Brussels — in the administration, in industry associations, non-governmental organisations and companies — should work on establishing conceptual clarity. Which of the three facets of carbon management is being addressed, and which CO_2 source (fossil, biogenic or directly from the ambient air) is being referred to? Furthermore, it is of central importance to clarify for what purpose carbon management approaches are to be used: to *reduce* or *delay* emissions that are hard-to-abate or to *counterbalance* residual emissions? The conflictual debates on CCS so far have shown that the intended role of a given carbon management approach in climate policy not only influences key regulatory details, but also shapes its political feasibility and degree of acceptance by the public.

Secondly, a platform is needed to develop a taxonomy of carbon management applications in the medium term. We are only at the beginning of a controversial discussion about what counts as the "legitimate" use of carbon management. The early development of a governance mechanism that does not administer the portfolio of approaches as an end in itself, but relates them to the objective of minimising hard-to-abate and residual emissions, can help avoid a polarised debate on the necessary capture, transport and storage infrastructures. Furthermore, such a platform would provide an opportunity to initiate an early governance framework for achieving net-negative greenhouse gas emissions beyond 2050. Eventually, there must be incentives to further reduce residual emissions and expand removal capacity beyond the net-zero year.

Thirdly, carbon management approaches will be necessary to achieve the net-zero emissions target. However, they are no substitute for drastic conventional emission reductions. Rather, they represent an additional challenge to achieving the EU's and Germany's climate goals. Tough political struggles lie ahead on how to address the issue of residual emissions at the interfaces of climate policy and other domains such as industrial and agricultural policy. A first step in this direction is the establishment of target designs that also include explicit objectives for minimum emission reductions as well as for the upscaling of CO_2 removal in the intermediate steps up to 2045 and 2050, respectively.

The upcoming political negotiations about the EU 2040 climate target and the expected amendment of the German Climate Change Act are crucial intervention points for the fundamental orientation of carbon management policy. It is important that the portfolio of approaches is not developed in a way that undermines the shift away from fossil fuels. An ambitious climate policy should use carbon management approaches strategically to overcome existing technical lock-ins, to disrupt political inertia and path dependencies, and to trigger innovation at the interface of industrial and climate policy that helps minimise and counterbalance residual emissions in the net-zero year.

This Comment reflects the authors' views.

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