acatech POSITION PAPER

CCU and CCS – Building Blocks for Climate Protection in Industry

Analysis, Options and Recommendations

acatech (Ed.)

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NATIONAL ACADEMY OF SCIENCE AND ENGINEERING

Contents

Executive Summary

The Paris Climate Agreement came about as a result of numerous scientific findings about the causes of climate change and the increasingly apparent serious impact of the human contribution to climate change. However, the steps the signatory states will have to take to achieve the self-imposed targets of the agreement also themselves have serious consequences. In Germany's case, these go far beyond the successful start which has been made to its energy transition that has so far primarily concerned the electricity sector. Major challenges remain in relation to heating, agriculture, transport and energy-intensive industries, specifically iron and steel production as well as the chemicals and cement industries. The direct impact on the population will be highly diverse: heating and insulation costs, diet, private transport, additional costs for building materials, metal products and chemicals, changes to the labour market.

This position paper focuses on German industry. The sector target for energy-intensive industries, which in 1990 accounted for around one fifth of Germany's greenhouse gas (GHG) emissions, is to cut emissions in half to 140 to 143 million tonnes of carbon dioxide equivalents (CO_2 equivalents) by 2030.[1,2] Emissions from this sector had already been cut to 188 million tonnes of CO_2 equivalents by 2016 thanks to many different measures. Further distinct reductions, however, remain to be made over the years to 2050. This raises important questions: are our societies, in Germany and the other signatory countries, ready for the necessary cuts which will arise from the goals agreed in Paris and specified in national Climate Action Plans? How can energy-intensive industry meet its challenges by 2030 and 2050? Have sufficient lead times been allowed for researching, planning, trialling and implementing technologies on the necessary scale? What changes can be expected on the labour market? There has so far been very little wide-ranging public debate about the consequences for each individual.

All options for reducing GHG emissions must be considered for industry. Essentially, the following options for avoiding CO_2 emissions can be identified and should be provided in this order of priority: firstly, avoidance of CO_2 emissions through higher efficiency, greater electrification and the use of alternative energy sources, processes and materials, secondly (re)utilisation of emitted CO_2 by extending material use, namely Carbon Capture and Utilisation (CCU), and thirdly long-term geological storage of otherwise unavoidable residual CO_2 emissions by Carbon Capture and Storage (CCS). It should, if required, be possible to re-extract stored CO_2 as a raw material.

It is generally assumed that emission reductions up to 2030 will be essentially achievable by material and energy efficiencies and by increased use of renewable energy sources. From 2030 onwards, when these potential savings will already to a great extent have been made, there will be an increasing need for new methods, materials and technologies which, in addition to using CO_2-free or -neutral energy sources, new processes and further electrification, also include CCU and optionally CCS. Both CCU and CCS are technically feasible and some approaches have already trialled at various scales, but there are substantial differences in terms of their strategic potential, how they can be integrated into CO_2 reduction scenarios and how feasible they are to implement depending on the outcome of prior debates regarding acceptability. The motives underlying the selection of CCU and CCS are also different.

CCU is primarily used for carbon circulation and GHG-neutral production with the concomitant climate protection effect being a welcome addition. There would appear to be potential for making repeated use of considerable volumes of industrially emitted CO_2 in conjunction with the production of synthetic motor and combustion fuels using renewable energy sources. However, there has not yet been any public discussion about the consequences, for instance a greater need to expand renewable energy considerably in the short term.

With CCS comparatively large volumes of CO_2 can be put into permanent geological storage in deep underground strata. There is a huge disparity between the levels of acceptance and the evaluation of the possible risks of CCS among the general public and in specialist circles. A politically successful protest movement has arisen against "CO_2 disposal sites", for which reason CCS is seldom openly discussed as an option even in political circles, so complicating the development of technology agnostic GHG neutrality strategies. CCS measures have previously mainly been discussed in connection with reducing CO_2 emissions from coal-fired power stations. The present position paper objects the idea that CCS makes sense for the power generation sector and limits itself to evaluating CCS for technologically unavoidable process-related CO_2 emissions from energy-intensive industries.

1 | Cf. BMUB 2016.

2 | Accounting as it does for around 86 per cent of total GHG emissions, CO_2 is the most significant greenhouse gas. Converting the global warming climate effect of other greenhouse gases into that of CO_2 allows total emissions to be stated as CO_2 equivalents.

The chemicals industry is dependent on carbon, currently predominantly obtained from fossil resources (oil, natural gas, coal), in many different ways. CO_2, like biomass, is an alternative carbon source and offers the possibility of at least partially closing the carbon cycle loop for industrial use. The potential offered by CCU applications in terms of sustainability essentially involves savings in fossil resources. In Germany, large-scale use of CCU technologies will to a great extent depend on its economic viability and on the availability of renewable electrical energy in terms of timing, location and volume. Technological innovations might in future expand the use of these technologies but the resultant climate protection effect will only be available on a large scale at some indeterminate time in the future. It would appear questionable whether industry will be able to meet its obligations arising from the Paris Agreement up to 2050 solely by applying all the above-stated CO_2 avoidance and reduction options and by utilising CO_2.[3] The fundamental political decisions which have yet to be taken in the present legislative period should therefore extend beyond the portfolio of these measures.

In contrast with the reticence towards CCS among some groups of the population, experts in engineering and geosciences can point to numerous years of experience in safe CO_2 storage, including beneath the North Sea, the Norwegian Sea and in Canada and the USA. In the light of the progress which has been made in safety engineering and if climate protection targets are to be achieved, even CCS sceptics should be able to regard CCS technology as a feasible way forward, especially since stringent testing and authorisation procedures ensure the risks are slight. In Germany, 2012's Carbon Dioxide Storage Act (KSpG) created no incentives to use CCS. The Federal States were given the option of an opt-out clause which has been widely exercised. It would be good to find out for the future whether they would be willing to review their decision in relation to using CCS for otherwise unavoidable industrial emissions.

As levels of CO_2 savings increase, further GHG reduction measures in industry will become more technically challenging which means that we have yet to face the more difficult stages of achieving climate targets. If CCS is ruled out as an option and full use has already been made of the other options or they can no longer be pursued or expanded at reasonable cost, little room for manoeuvre remains. It is therefore doubtful whether it makes sense to maintain Germany's current absolute prohibition of CCS.

Just as at the start of the debate about the use of CCS around a decade ago, there is still no clear roadmap for large-scale use of CCU and CCS technologies. Numerous national and international scientific studies view both approaches, CCU and CCS, to be conceivable building blocks, if not an essential mainstay, for cost-effectively achieving the climate policy targets of the Paris Agreement.

Successfully achieving CO_2 reductions in industrial processes using CCU and CCS technologies will only be possible if these technologies enjoy broad support from civil society and major players from industry, politics, interest groups and science. CCS technology in particular will only be an option for further CO_2 reductions if it is accepted by Germany's citizens. The technologies which, on the basis of current knowledge, will be required, especially from 2030 onwards, will have to be further developed and brought to market maturity in the near future if they are to be available in time. The necessary infrastructure must be planned, approved, funded and built, preferably in industrial regional clusters, spanning corporate and sector boundaries. Given the long lead times involved, it is vital to pay attention now to issues around suitable business models and the funding of the necessary infrastructure.

In the case of CCU, the priority is to further develop technically, environmentally and economically implementable technologies and to have them recognised as sustainable CO_2 reduction methods for the purposes of the national climate protection targets.[4] In the light of the widespread reservations regarding CCS technology, there is an urgent need for a thorough debate with all stakeholders to establish whether, in which sectors and to what extent CO_2 storage might be applied. In order to create a willingness to use CCS, any deep underground CO_2 storage should be limited to otherwise unavoidable CO_2 emissions from industry. It must moreover be clarified to which energy-intensive industry emitters CCS should be available as a priority, for how long (if it is a bridge technology), who will provide the infrastructure for transporting and storing CO_2, how can this be achieved at the lowest possible cost while ensuring the highest safety standards, where should storage preferably be located (onshore and/or offshore) and who will bear the costs? Devising planning principles, creating social consensus and the administrative and engineering implementation require a focused and thorough approach.

3 | Global climate protection scenarios accordingly indicate that achieving the 2 degree target will probably, and certainly in the case of the 1.5 degree target, entail removing CO_2 from the atmosphere ("negative emissions"). In January 2018, the European Parliament resolved to cut CO_2 emissions to zero by 2050 and afterwards to ensure net removal of CO_2 from the atmosphere (European Parliament 2018). Even optimistic scenarios assume that some 14 million tonnes CO_2 equivalents from industry, especially the cement and lime industry, are unavoidable (UBA 2015).

4 | Uniform assessment criteria and standards over the entire life of any CCU products are required for this purpose (Life Cycle Assessment).

Overall, it is also necessary to come to an understanding as to how far CCU and CCS are or will have to be elements of an overarching GHG neutrality strategy. Publicly funded innovation programmes and financial assistance in the construction of transport and storage infrastructure will play a vital role in development and market introduction. It should also be established whether and to what extent CCU and CCS will in future be capable of contributing to Germany's industrial competitiveness. German companies are contributing to climate protection around the world with their innovative products and systems and so create growth and jobs in engineering and plant construction, in the electrical industry or with smart control engineering. Given appropriate adaptation, it should be possible to maintain existing value chains and successful industry clusters and to reconcile GHG neutrality with industrial competitiveness. Early development of the necessary infrastructure can bolster belief in the survival and future success of industrial production lines and clusters and also help to maintain Germany's position as a model of technological innovation.

It is obvious that we need a new, unprejudiced debate about whether we wish to make use of CCU and CCS as options for significantly reducing CO_2 emissions from industry and, if so, under what conditions. If we take the Paris Agreement seriously, we must make a start today.

The intended audience for this acatech POSITION PAPER primarily includes political actors and interested members of the general public, decision makers and experts from all areas of the industries concerned as well as possible funding providers and investors. The position paper is intended to inject impetus in three ways:

- Firstly, the position paper is intended to make a scientifically well-founded contribution to the further development of Germany's climate protection strategy and address fundamental issues of broad use of CCU and, for technologically unavoidable emissions from essential industrial processes, of CCS as possible climate protection building blocks. The Federal Government's coalition agreement commits it to the 2020, 2030 and 2050 climate targets agreed in the Paris Climate Agreement and to being technology agnostic.[5] Pointing out the opportunities, risks and limitations of CCU and CCS with regard to CO_2 reduction options and their public perception is intended to provide important indications regarding the possible use of these technologies in energy-intensive industries.
- Secondly, the position paper indicates the technological significance of and the possible contribution to climate protection by CCU and CCS in reducing CO_2 emissions from energy-intensive industries. The industries in question, including chemicals, iron and steel as well as cement, are of huge significance to the economy. Research and development into emission reduction measures boost Germany's ability to innovate and create value.
- Thirdly, the paper hopes to kindle a broad social debate about possible approaches to reducing emissions from industrial processes by means of CCU and CCS and their implications. Cooperation between science, industry and society would appear to be absolutely essential with regard to the use of CCU and CCS due to their highly interdisciplinary nature, great technological complexity and the significance of the industries involved to employment.

5 | Cf. German Federal Government 2018.