



CO₂ Capture and Storage – Only an Interim Solution

Possible Impacts, Potential and Requirements

- summary -

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Climate change constitutes a huge challenge for humankind. Greenhouse gas emissions are still continuing to increase on a global scale. In order to limit the risks of global climate change, global average temperature must not rise more than 2° C above pre-industrial levels by the end of this century. If this target is to be achieved globally, Germany - like the other industrialised countries - must reduce its emissions of greenhouse gases by 40% by 2020 and by 80% by 2050 compared to 1990 levels.

The German Federal Environment Agency (Umweltbundesamt, in short “UBA”) banks on a sustainable climate protection policy through emission prevention and is therefore demanding that, as a priority, the change initiated in German energy policy - away from fossil fuels towards renewable energy sources and a marked increase in energy efficiency – should be consistently implemented and intensified, i.e. that emissions be addressed before they occur.

For a limited time, there may also be a need to take end-of-pipe measures to reduce CO₂ emissions. This may include certain forms of capture and storage of the most important greenhouse gas, carbon dioxide, often referred to as CO₂ “sequestration”. Although CO₂ capture and storage does not prevent continued generation of greenhouse gases, it does promise to prevent their escaping into the atmosphere and, thus, their climate impact for extended periods of time.

The Federal Environment Agency takes the view that for the use of such methods it is essential to also take into account their impact on other spheres of the environment and health issues. The Agency has developed a detailed opinion on these issues in a comprehensive position paper, which is available from October 2006 in German on the internet website of the German Federal Environment Agency

www.umweltbundesamt.de/energie. This summary outlines the major conclusions. Both national and international aspects need to be considered in the discussion.

Where national aspects are concerned, the Federal Environment Agency focuses on the situation in Germany, e.g. in addressing the question of available storage capacity for captured CO₂. This paper deals only with CO₂ capture and storage, and not with biological ("terrestrial") sequestration through, for example, forestation.

Argument 1: Climate protection can be achieved with renewable energy sources and energy efficiency. CO₂ capture and storage is non-sustainable and at best an interim solution.

Climate protection scenarios of the Federal Environment Agency and other researchers show that the climate targets can be achieved by increasing energy efficiency and expanding renewable energies. For this reason, the Federal Environment Agency favours fastest-possible implementation of these measures over CO₂ capture and storage. The latter is based on the combustion of fossil resources whose availability is globally limited and focused on a few regions. Coal will be available for several more centuries even if current consumption rates see a significant increase. However, since large amounts of the greenhouse gas CO₂ are released in the combustion of coal, its increased use would prevent attainment of the 2° C target. In other words, the availability of coal significantly exceeds the amount of carbon dioxide, its combustion product, which the earth's atmosphere can absorb without doing harm to the global climate.

Where pursued, the development of geological sinks for captured CO₂ in addition to that of natural sinks may allow for some additional time until the reduction and prevention measures which the Federal Environment Agency considers a priority become fully effective. However, also geological sinks are limited (cf. Argument 2). Furthermore, the additional energy required for capture will reduce the lifetime of fossil resources. For this reason, CO₂ capture and storage is not a viable option and not sustainable. It represents at best an interim solution to the climate protection challenge, provided that the framework conditions set forth below (cf. Arguments 4 – 6) are met.

In Germany, power producers will have to replace considerable power plant capacities by 2020. Even with ambitious renewable energy and energy saving targets, some of these power plants will continue to be fossil-fuel-based. In order to achieve the climate protection target of -40% by 2020, conventional coal-fired plants may only play a minor role among new power plant installations, because CO₂ capture and storage power plants are not expected to be available on a commercial scale before 2020 in Germany. Retrofitting existing coal-fired power plants is likely to imply disproportional and resource-intensive expenses. For the power plants currently planned for construction, alternatives lie in the increased use of natural gas in highly efficient combined cycle power plants or in small, decentralised cogeneration plants. As natural gas resources are also limited and involve continued emissions of carbon dioxide, these alternatives likewise represent only an interim solution; however, their advantage is that they are available today.

This means that CO₂ capture and storage cannot make a relevant contribution to climate protection up until 2020. Even after that time, this technology will be relevant only for large installations, mainly power plants, due to the costs involved. Hence, this technology alone is not capable of stopping climate change. Having this in mind, priority must be given to those measures, which are available now and in the long term, this is to say increased efforts for the promotion of energy efficiency and renewable energies.

Current German research support policy reflects these priorities in a well balanced manner. The Federal Government spends approximately EUR 130 million annually on support for research into renewable energies and EUR 80 million on the promotion of more efficient technologies, compared to EUR 18 million for research into CO₂ capture and storage.

A prioritisation along these lines should also be applied in international cooperation in climate protection and EU research policy.

Argument 2: The discussion needs to focus on CO₂ storage capacities: In Germany, they could, mathematically, be limited to 40 years.

Possible sites for CO₂ storage are, mainly, decommissioned oil and gas fields as well as saline aquifers (deep water-bearing strata). Since the cost of CO₂ storage rises with increasing transport distance, storage is likely to take place within Germany or in areas close to the border to Germany.

Germany has significant storage capacities in former gas fields, to the tune of 2.5 gigatonnes (1 Gt = 1 billion tonnes) of CO₂, in contrast to the low existing capacities in former oilfields. In addition, it has storage capacities in saline aquifers, which could range between 12 and 43 Gt of CO₂.

Based on the lowest capacity figures, CO₂ storage capacities in Germany would be limited to about 14.5 Gt CO₂. Assuming complete storage of all current power plant emissions, the current CO₂ emissions from German power plants of about 0.35 Gt CO₂/year would, mathematically, fill this volume in 41 years. If the higher CO₂ storage capacity figure of 45.5 Gt CO₂ is taken as a basis, storage capacities could, mathematically, last for a period of 130 years.

These mathematically constructed values indicate upper limits due to costs and environmental concerns. Further on, some repositories will not be usable as a consequence of ecological and health considerations. In addition, CO₂ storage in the available repositories will compete with their use for generation of geothermal energy and for storage of gas or compressed air. This contention will play a decisive role for climate protection. Lastly, not all repositories will be usable under economically favourable conditions.

Argument 3: CO₂ capture and storage entails costs. However, given ambitious climate protection targets, some projects will probably be economical.

The capture of CO₂ entails costs. Further costs will arise for compressing the CO₂ for transport in pipelines and ships as well as for storage and for monitoring the repositories. Therefore, CO₂ capture should only be used if it proves to be a cost-efficient climate protection measure in comparison with other options.

The estimates available to the UBA of how high these costs will actually be do not only depend on the technology used. They are also determined by numerous other factors which their authors do not always describe in a transparent manner. Capture constitutes the largest cost factor and amounts values between EUR 8 and 68 Euro per tonne of CO₂. For comparison, CO₂ allowance prices within the EU emissions trading scheme have varied between EUR 6 and 30/tonne of CO₂ to date (as at August 2006).

CO₂ capture and storage can make business sense if the emission of CO₂ is subject to costs. On liberalised energy markets, it is ultimately the investors' costing that will decide the realisation of CO₂ capture and storage projects. However, the large-scale use of this technology requires ambitious climate protection objectives that go far beyond the Kyoto protocol commitments. The more expensive emissions of CO₂ to the atmosphere are, the more worthwhile CO₂ capture and storage will be. This has also been demonstrated by scenario calculations on the use of CO₂ capture and storage.

The extent to which CO₂ capture and storage will be used will also depend on the development of competing technologies. Pipeline infrastructure will have to be built for CO₂ transport. Before this happens, the viability and development potential of other large-scale technologies to reduce national CO₂ emissions on the basis of renewable energy sources, e.g. the import of electricity generated from solar thermal energy from sunny regions, should be assessed.

Argument 4: CO₂ repositories should not exceed a leakage rate of 0.01% per year. Risks to health and the environment need to be avoided.

Any CO₂ repository in use today has to be regarded as a potential emission source of tomorrow. The security of storage depends mainly on the site-specific characteristics of the geological formation. Another key issue is the long-term safety of borehole seals. Therefore, binding safety requirements and prescriptive limits for maximum-permissible annual emissions of CO₂ from repositories need to be established.

The limit value for leakage has to be defined so as to exclude a risk to humans and the environment from escaping CO₂, e.g. toxic CO₂ concentrations at ground level or near the surface. Furthermore, other negative effects on the environment such as shifts in pH in ocean water and groundwater need to be avoided. Also climate protection considerations are a central aspect: Subsequent generations must not be exposed to emissions of greenhouse gases via leakage from CO₂ repositories. The Federal Environment Agency therefore advocates a maximum annual leakage rate of 0.01%. Mathematically, this means that 1000 years after initial storage 90.5% of stored CO₂ will still be in the repository, unless some of it has already been permanently bound in the underlying soil by natural geo-physicochemical processes.

CO₂ captured from the flue gas of power plants is not pure but normally contains further chemical compounds which can originate from the input materials and result from the removal process. Depending on the source, this may include toxic, bioaccumulative or persistent substance groups that may pose a considerable hazard to humans and the environment during storage or when released as a result of accidents, acts of violence or leakage. Given the amounts of CO₂ to be stored, these additional substances may, in absolute terms, be present at relatively high tonnages even if their percentage in the gas is small.

Maximum-permissible values for pollutants in CO₂-bearing flue gas destined for storage should be comparable to the requirements for flue gas discharged to the atmosphere as laid down in pollution control legislation. Nor may these pollutants impair the safety and functional reliability of the facilities or the long-term stability of the repository and borehole seals. Subsequent addition of other pollutants to stored CO₂ must be prohibited.

Argument 5: Storage of CO₂ in the ocean water column and “artificial mineralisation” of CO₂ are not an option

In addition to geological storage (e.g. below the seabed), the discussion is also focussing on storage in the ocean water column (ocean storage). CO₂ is toxic in high concentrations and would therefore adversely affect marine organisms in the vicinity of CO₂ injection sites. This may potentially result in the death of marine organisms. CO₂ reacts with water to form a weak acid and may cause the acidity (pH) of seawater to change when injected in large amounts. The ocean currents connect the deep sea with the ocean surface, with the result that CO₂ stored in the water column or on the seabed can return to the surface relatively quickly and be released to the atmosphere. For this reason, the storage of CO₂ in the water column or as a “CO₂-lake” on the seabed is not acceptable. It must be prohibited by international law.

Another storage option currently under discussion is “artificial mineralization” of CO₂. This refers to a technique in which CO₂ and an initial mineral react chemically to form a new mineral which permanently binds the CO₂. However, the processes that are known are inherently extremely energy-intensive and therefore compromise the value of the overall process. Furthermore, this type of CO₂ storage requires large amounts of parent material, and each tonne of stored CO₂ generates 3 to 8 times more waste and spoils which have to be transported and stored. Since it can already be anticipated that “artificial mineralization” will not be acceptable for environmental and cost reasons, this form of storage should not receive public funding.

Argument 6: The national and international legal framework for CCS needs to be developed

There is currently no legal framework specifically developed to cover the capture, transport and storage of CO₂, neither in Germany nor internationally. A number of regulations – such as waste and mining legislation, in the national context, and international agreements for protection of the marine environment – need to be further

developed to regulate the capture and storage of CO₂. From the viewpoint of the Federal Environment Agency, the development of the legal framework should take the form of defining specific requirements that are geared to sustainability criteria.

What is needed primarily is legal cover for site exploration, mandatory authorisation of individual storage sites and storage operations, and the development of suitable standards that exclude both short-term and long-term damage to health and the environment. In addition to designing these regulatory requirements, liability legislation needs to be further developed. Provisions must be in place to ensure that the cost of eliminating accident-related damage is not shouldered by the general public. In view of the long storage period, questions of legal succession of the companies that use or have used the repositories must also be clearly regulated.

Another question that needs to be resolved is who is responsible for monitoring CO₂ repositories and how – in view of the necessary long storage period (> 1000 years) – the professional requirements related to monitoring can be adequately implemented. Moreover, continuous releases from the repositories need to be adequately taken into account in the recognition of CO₂ emission abatement measures under the Framework Convention on Climate Change and in emissions trading.

Argument 7: Environmental aspects and international justice need to be part of the discussion. Research, State regulation, and demonstration projects must not focus on technical aspects only.

Up until now, the discussion of CO₂ capture and storage has been largely confined to technical aspects. This is reflected in national research activities within Germany as well as in international research cooperation. Given the existing uncertainties this is – no doubt – an important part, but not sufficient for the preparation and possible implementation of CO₂ capture and storage.

In the interests of the general public, of public acceptance, of the environment and long-term climate protection – and also in the best interests of potential investors – the Federal Environment Agency would like to initiate a discussion on whether CO₂ capture and storage should be used to help Germany and other industrialised countries to achieve their climate protection targets and, if so, what form this contribution could take. At the same time, it is necessary to integrate environmental concerns and notions of international justice into the international dialogue and to design the legal framework in a manner which renders energy supply affordable, reliable, environmentally sound and climate-friendly for today's and future generations to come.

The long version of the position paper is available in German from October 2006 for download on the website of the Federal Environment Agency
<http://www.umweltbundesamt.de/index-e.htm>.