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CCS for climate protection – important, tedious and costly

- **Global energy consumption is rising and still relying heavily (80%) on fossil fuels. In the emerging markets, in particular, additional energy requirements are met by coal as this inexpensive and flexible commodity is in abundant supply. According to the International Energy Agency (IEA), the share of coal in the increasing consumption of primary energy will rise further until 2030, resulting in increasing CO_2 emissions. In 2010 alone, global CO_2 emissions rose by approximately 5% yoy to a new record high.**
- **In light of this negative outlook for the world's climate, many market experts have stressed the importance of CCS (carbon capture and storage) technology. The IEA estimates that up to 20% of the 50% reduction of energy-related greenhouse gas emissions required for meeting the global climate target could be achieved by means of CCS.**
- **The fact that CCS is technically feasible is largely undisputed. However, there are major obstacles. In Germany, these obstacles are mainly political as the technology does not seem to stand a chance in light of the threat of public protests.**
- **Outside Germany and the EU, it is above all the lack of price signals for CO_2 that renders the use of CCS more difficult. Nonetheless, most of the world's leading industrialised nations say they want to step up their research in this area, and have earmarked USD 40 bn to do so.**
- **CCS is only one of the pillars for meeting the 2°C target, but one which under current and expected circumstances does not seem able to bear its load as planned. Further measures will be necessary.
These include increasing energy efficiency and placing a stronger focus on renewable energies. Many countries still rely on nuclear energy – despite the Fukushima disaster.**

Energy demand and CO_2 emissions on the rise

The International Energy Agency (IEA) reported recently that global CO_2 emissions were up 5% yoy in 2010, thus reaching a new record high. This was caused by the rapid economic upswing in many parts of the world. Over 80% of global energy supply relies on fossil fuels. In the developing countries and emerging markets in particular it is coal, above all, that satisfies the additional hunger for energy. Coal is relatively inexpensive, available in abundance in many countries and deployable for numerous purposes: to provide electricity and heating and – after gasification or liquefaction – even fuel for mobility applications. According to the IEA, coal accounted for roughly 44% of global energy-related CO_2 emissions in 2010. In 2004 the share had only come to 40%. Hence, coal clearly outstrips oil and gas. In the IEA's business-as-usual scenario, global primary energy consumption will rise by 1.5% p.a. up to 2030. The share of coal looks set to grow by roughly 2 percentage points to 29%.

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CCS: Methods and risks

Generally speaking, there are three methods that can be used to **capture** CO_2:

- Pre-combustion method: In a gasification process, the fossil fuel (e.g. coal) is converted to a mix of CO_2 and hydrogen. The CO_2 can then be captured and the hydrogen can be burnt.
- Post-combustion method: CO_2 is only removed after the combustion of a fossil fuel. This technology can be added to existing power stations and industrial plants.
- Oxyfuel method: Coal is combusted with pure oxygen which must first be produced. The flue gas then consists mainly of steam and CO_2 which can be easily separated.

For carbon **storage**, there are the following options:

- Saline aquifers on land or below the seabed;
- Depleted oil or gas fields or coal seams;
- Enhanced oil/gas recovery;
- Storage in deep sea sediments (two methods with different water depths: at least 1,000 and 3,000 metres, respectively).

If underground storage of CO_2 is not possible where it is produced, it must be **transported** to the place of storage. In the case of enhanced oil recovery, pipelines have proved to be a suitable means of transport. Ships may be used for sea transport.

The following are considered typical **risks** regarding CCS technology:

- If the sites cannot store CO_2 over the long term, the climate will not benefit – on the contrary. In addition there would be health hazards in case of large-scale leakages near human settlements.
- Groundwater quality could suffer when CO_2 is stored in saline aquifers.
- Another risk in sub-seabed CO_2 storage is ocean acidity.

Experience with CCS technology so far has shown that the risks are basically manageable, even though not all methods have been researched and tested.

Factoring in the lower degree of efficiency and energy consumption of the CCS process itself, the technology can help achieve a **reduction of CO_2 emissions** of approx. 80% to 90% compared with traditional methods.

Sources: Albrecht, Jutta et al. (2011). Kurz zum Klima: Kohlenstoffsequestrierung – lässt sich das Klimaproblem einfach “begraben”? ifo Schnelldienst 6/2011. Munich. e on (2009). CO_2-Abtrennung und -Speicherung. CCS – Für den Weg in eine nachhaltige Energiepolitik. Dusseldorf.

For climate protection, this development would be disastrous as annual energy-related CO_2 emissions would then rise to roughly 40 bn tonnes by 2030. To meet the global climate target – limiting the rise in temperature on Earth compared with pre-industrial levels to 2°C at the most – “only” about 750 bn more tonnes of CO_2 from fossil sources could be allowed to be released into the atmosphere by 2050.[1]

Hence the significance of carbon capture and storage (CCS) is being stressed by many experts, as it would make the use of coal (and other fossil energy sources or industrial processes) more climate-friendly.[2] Both the Stern Review of 2006 and the Intergovernmental Panel on Climate Change (IPCC) have pointed out that the 2°C target will be hard to meet without CCS. In an energy scenario for the year 2050, which foresees the reduction by half of global energy-related greenhouse gas emissions by that year, the IEA puts the contribution from CCS at just under 20%. This scenario attaches almost the same significance to CCS as renewables.[3]

According to the Global CCS Institute, there are more than 200 projects worldwide in which the technology is being tested and/or used; only a few of them are large commercial CCS projects.[4] The best-known one is the Sleipner gas field in the Norwegian part of the North Sea. The natural gas extracted here has a relatively high CO_2 content which is stripped from the gas stream still out at sea and compressed underground. Hence, the operating company can avoid paying Norwegian tax on carbon dioxide emissions. In other cases, CO_2 is pumped into oil or gas fields to boost exploitation volumes (enhanced oil/gas recovery).[5] In both cases there is obviously a strong economic incentive to use CCS.

One thing is clear, though: CCS is technically feasible, even though there are very many differing methods featuring varying degrees of maturity (see box).[6] Moreover, the geological preconditions for CCS are not in place everywhere. Experts are expecting and hoping that, from 2020 at the latest, the technology will be marketable for large-scale application in power plants and industrial works.

Incentives for CCS insufficient at present

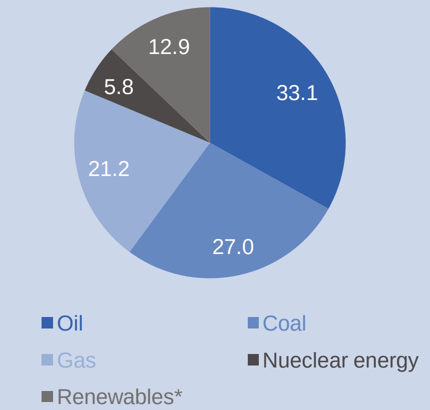
The EU, the US, China and other countries intend to intensify CCS research in order to further explore the opportunities and risks of this technology. According to the Global CCS Institute, government funding to promote demonstration projects amounts to USD 40 bn worldwide. In an EU directive from 2009 member states are called upon to create the required legal framework. Similar legislation on CCS is also underway in the US.[7]

At first glance there is a lot to suggest that CCS technology will experience a breakthrough in the years to come. But a closer look reveals that doubts are justified. In Germany, for instance, the technology already seems to have failed for political reasons, even before it could be tested on a larger scale. In light of imminent public

[1] See WBGU (2011). Welt im Wandel. Gesellschaftsvertrag für eine große Transformation. Berlin.
[2] See Auer, Josef (2007). Technology to clean up coal for the post-oil era. Deutsche Bank Research. Current Issues. Frankfurt am Main.
[3] See IEA (2008). CO_2 capture and storage. A key carbon abatement option. Paris.
[4] See Global CCS Institute (2011). The global status of CCS: 2010. Canberra.
[5] This method will then indirectly push up CO_2 emissions again.
[6] For more detailed information on different CCS methods, see for instance IPCC (2005). Carbon capture and storage. New York. See also IEA (2008) loc. cit.
[7] See IEA (2011). Carbon capture and storage. Legal and regulatory review. Paris.

Fossil fuels predominant

Global primary energy consumption, percentage share, 2008

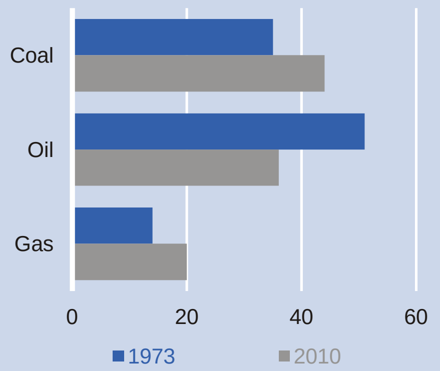


*Mostly biomass and hydropower.

Source: IEA 1

Coal largest source of CO_2

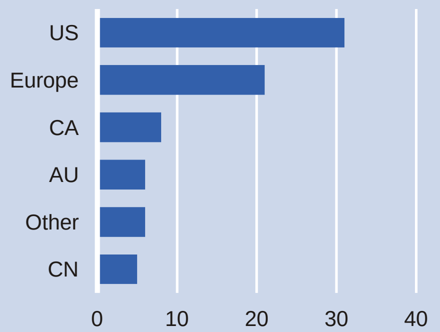
Share of energy sources in energy-related CO_2 emissions (%)



Source: IEA 2

US and EU are CCS leaders

Number of large-scale integrated CCS projects*



*Comprises all projects irrespective of their progress.

Source: Global CCS Institute 3

protest against underground storage of carbon dioxide, no political party is currently willing or able to create an environment which would give CCS a genuine chance in Germany. The federal government's draft legislation on CO_2 storage leaves the decision to the federal states as to whether or not storage facilities should be allowed. Apart from Brandenburg, which already hosts a demonstration project, all Länder governments have already rejected CO_2 storage. Most other EU countries have no legal framework for testing and using CCS either, even though the economic preconditions for CCS in both Germany and the EU are actually favourable. For EU emissions trading puts a price tag on CO_2, and reducing emissions via CCS could make financial sense for the energy utilities from a certain certificate price (from approximately EUR 35 to EUR 50 per tonne of CO_2). In this case, an economic incentive would become the driving force for CCS again. At present the price of CO_2 is still considerably lower (approx. EUR 13 per tonne).

Lack of price tag for CO_2 a major obstacle

Outside the EU, politicians have also come out in favour of the technology. The largest obstacle preventing the widespread use of CCS is probably the fact that CO_2 has no price outside the EU and that there is no regulation as to how the technology is to be used. In such an environment, CCS will hardly stand a chance. Equipping plants with CCS technology is expensive; the Global CCS Institute estimates that the additional cost compared with conventional power plants runs to between 40% and 75%. Moreover, the technology reduces the degree of efficiency of coal-fired plants, for instance, by 10-50% depending on the CCS method used. This means more coal must be employed to produce the same amount of energy as before. Why should companies be willing to pay such a price if there is neither a price for CO_2 nor an obligation to use CCS?

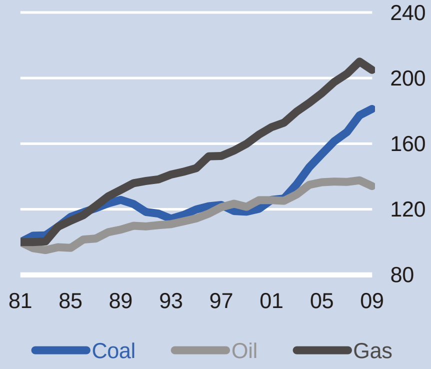
Neither the US nor China nor any other large economy has as yet formulated binding emission reduction targets in international negotiations on climate change. And currently there are no signs that this situation will change in the coming years. China, in particular, is interested in producing as much cheap energy as possible to fuel its economic upswing, despite all (successful) efforts to boost that country's energy efficiency.[8] In this context, CCS would tend to weigh it down. In the US there is currently no political majority visible that would promote the introduction of emissions trading (and thus a pricing mechanism for CO_2) or the obligatory use of CCS. Without government regulation, CCS would probably be used, if at all, to better exploit oil and gas deposits.

So is hope all that remains for protecting the climate?

Let's summarise our findings up to now: global energy consumption is increasing; the share of coal in energy supply will grow in the long run; and there is little incentive to use CCS. In view of our changing climate this is a depressing outlook as in this scenario we will not see greenhouse gas emissions peak worldwide by 2020, which is seen as a precondition for meeting the 2°C target. From a current

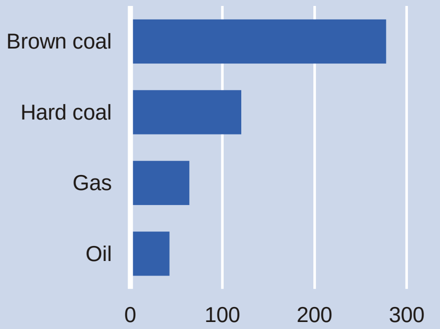
[8] China intends to lower CO_2 emissions per unit of GDP by 45% until 2020 compared with the 2005 level. In addition, the country is investing massively in renewables. It ranks first globally in terms of its wind power capacities. In this context, industrial and climate policy reasons play a part. At the same time, China is seeking to reduce its dependence on fossil fuels and reduce pollution levels especially in its cities. Nonetheless, plant capacities based on coal will far more than double by 2030, according to the IEA.

Coal and gas production growing rapidly
Global output by volume, 1981=100



Source: BP 4

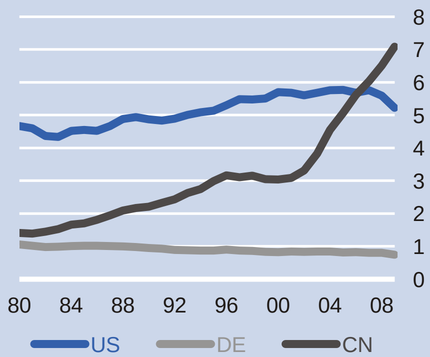
Coal in abundance
Statistical reach* of fossil fuels, years



*Ratio of current reserves that can be tapped in commercially feasible volumes to current production volumes.

Source: BGR 5

China running at full throttle
Energy-related CO_2 emissions, bn tonnes



Sources: IEA, BP 6

vantage point it seems doubtful that the (political) environment will change dramatically in favour of CCS after 2020, i.e. when CCS technology will have reached maturity. Any new power plants that will be built by that time, especially in the emerging markets, are unlikely to be (retro-)equipped with CCS technology – if at all, only at very high cost. The IEA recently pointed out anyway that 80% of total greenhouse gas emissions from the energy sector up to 2020 could no longer be avoided as they would stem from existing plants or plants that are currently under construction.

What can be done? Should the major forecasts for climate change actually materialise, the economic costs would be huge. One important message in the Stern Review was that it will be cheaper to avoid the negative consequences of climate change than having to adapt to them at a later stage.

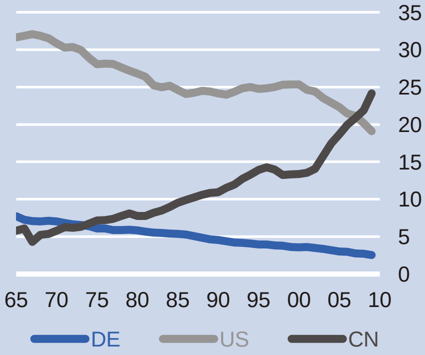
Europe needs more political courage and better communication in order for CCS technology to stand a chance of widespread implementation in the energy and industrial sectors. One potential driver of CCS in developing countries and emerging markets could be to recognise CCS projects implemented there under the Clean Development Mechanism (CDM): both, countries and companies running CCS projects there would then be able to credit the emissions certificates generated in this way to their own reduction targets. This option has been discussed at the UN level for years now – thus far to no avail. Also, funding CCS projects by means of climate funds would be another way of introducing the technology in poorer states. Moreover, a price for CO_2 should be set as soon as possible outside the EU as well. This price should ideally reflect the atmosphere's limited absorption capacity for greenhouse gas. Emissions trading that were to include the world's leading economies, resulting in a unified price for CO_2, could give a boost to CCS technology. At present, however, this seems highly unlikely.

Further measures required to protect the climate besides CCS

CCS is no cure-all for climate change. CCS notwithstanding, it is necessary to raise energy efficiency further in all major economies to meet the global climate target. But here, too, the speed at which progress is being made is still too low and price signals via taxes or certificate prices are not strong enough in many countries (e.g. the US and China). Also, the development and expansion of renewable energies and storage facilities are among the key mechanisms in efforts to protect the climate. In this context, the best location for renewables is an important issue. Most renewable energy sources can only hold their own in the competition with fossil fuels (among other things due to the lack of a price for CO_2) thanks to large-scale subsidisation; for poorer countries, in particular, they are simply too expensive. Technical progress must be achieved to bring down costs further. Boosting the CO_2 efficiency of energy production can be achieved by, say, switching from coal to gas. Moreover, with an eye to the low greenhouse gas emissions, many countries still rely on nuclear energy – despite the Fukushima catastrophe and the as yet unresolved issue of permanent repositories. In weighing up the risks of a nuclear accident against those of climate change, these countries obviously arrive at a different conclusion than Germany. Of course, the major driving force in expanding nuclear energy is greater security of supply and to a lesser extent climate protection.

Outside the energy sector, efforts must be stepped up in the area of forest conservation, as the deforestation is responsible for roughly 17% of global anthropogenic greenhouses gas emissions. The huge

US overtaken by China
Share of global energy-related CO_2 emissions (%)



Source: BP 7

significance of forests has meanwhile been acknowledged in international climate negotiations. Forest conservation is to be rewarded by means of the so-called REDD mechanism (Reducing Emissions from Deforestation and Forest Degradation). Basically, the idea is to reward developing countries and emerging markets for conserving their forests via financial transfers. However, this plan has yet to be hammered out in greater detail. And finally, anyone intent on curbing the rise of global energy consumption will also have to attempt to stem global population growth. As the reality shows, this is another problem that is difficult to solve.

In the final analysis, merely considering the facts will lead to a pessimistic conclusion, namely that the 2°C target can hardly be met under the current circumstances. Even an ambitious climate target in Germany or the EU cannot change this, as the EU's share in global greenhouse gas emissions is declining constantly; for Germany, the figure currently comes to below 3%. Fatih Birol, chief economist of the IEA, recently referred to the 2°C target as a “nice utopia”. Nevertheless, we should still aim to meet the target, but in light of this outlook adapting to climate change will probably be paid more attention in the future than it has been in the past.

Conclusion: CCS contribution to climate protection in jeopardy

CCS is only one pillar in international climate protection policy, but certainly an important one. However, it currently does not seem likely that this pillar will be able to bear its load as planned for the coming two decades. Without CCS, though, the 2°C target would be in even greater jeopardy than it already is. Politicians’ general commitment to CCS and the realisation that the technology can make a valuable contribution to climate protection must therefore be followed by action: first and foremost, further research must be carried out and, second, price signals for CO_2 would be required for its implementation.

The “best of all worlds” for climate protection would of course be achieved if it were possible not only to store CO_2 but also to turn it into a useful commodity (carbon capture and usage, CCU). In this paper, we do not want to discuss the various chemical and biological approaches to using CO_2. However, major problems are to be expected as the usage of CO_2 would have to be relatively inexpensive and large amounts would have to be captured to make a meaningful contribution to climate protection. Finally, CO_2 would have to form the basis for products that achieve a price, which in turn implies a price for CO_2 itself. In any case, it seems worthwhile to intensify research also in the area of CCU.

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