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"Negative Emissions": A Challenge for Climate Policy

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The objective of the Paris Agreement is to limit global warming to well below 2 degrees Celsius, and to pursue efforts to limit the temperature increase to 1.5 degrees. The Intergovernmental Panel on Climate Change (IPCC) believes that these targets cannot be reached through conventional mitigation measures alone. The IPCC assumes that in addition to reducing emissions, technologies for removing greenhouse gases from the atmosphere will become indispensable. The preferred technology option combines increased use of bio-energy with the capture and storage of carbon dioxide. To date, climate policy has largely ignored the necessity for "negative emissions" to achieve the temperature targets set out in the Paris Agreement. Discussions on the underlying model assumptions, potentials and risks of imaginable technological options, as well as their political implications, are only just beginning. It would be wise for the EU and Germany to proactively shape this debate and increase funding for research and development. If the Paris climate objectives are upheld, climate policy pioneers will soon be facing calls to set emission-reduction targets of much more than 100 percent – a notion that today seems paradoxical, but may soon become reality.

Global climate stabilisation targets, such as restricting global warming to 1.5 or 2 degrees Celsius (°C) above pre-industrial, are usually translated into carbon budgets that show the total amount of emissions that would still be allowed for meeting the target. According to current calculations, the remaining emissions budget for the 2 °C target is about 800 gigatonnes (Gt) of carbon dioxide (CO_2). However, for 1.5 °C, it is only about 200 Gt. Given that annual CO_2 emissions currently stand at about 40 Gt, the world's budget for 2 °C would be consumed by the mid-2030s, the budget for 1.5 °C as soon as the early 2020s. Since completely decarbonising the world economy within a time frame of only 5 to 20 years is unrealistic, climate models build on the concept of negative emissions. By using technologies to remove CO_2 from the atmosphere, the original emissions budget could initially be overshot, with the resulting deficit then being recouped over the course of the 21st century. However, the looming budget deficit has now reached an alarming size. The IPCC's climate models show

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that a total of 500 to 800 Gt in negative emissions would have to be generated by 2100 to limit global warming to 2 °C or 1.5 °C – in other words, up to twenty times the current annual CO_2 emissions.

In principle, all governments accept the scientific consensus set out by the IPCC in its 5th Assessment Report (2013-2014). The report points out that negative emissions cannot be avoided if ambitious climate targets are to be met. Currently, however, there is hardly any discussion on how to bring about negative emissions. This is particularly worrying because building the necessary capacities would have to start by 2030 at the latest. Since there is no political debate on negative emissions yet, potential conflicts of interests or public acceptance problems can only be guessed at. The possible social and ecological consequences of such a far-reaching use of technologies for CO_2 removal have barely been examined. The biggest problem, however, is that almost all the technological options currently being favoured are still in the early stages of development, making their potential for successful deployment extremely uncertain.

Technological options

In its current climate-economic models, the IPCC almost exclusively refers to a technological option that combines planting fast-growing biomass, burning it in power stations to generate electricity, and capturing and storing the CO_2 that is released in the process (bio-energy with carbon capture and storage – BECCS). During its growth phase, the biomass absorbs carbon dioxide from the atmosphere that is then captured during combustion and subsequently stored, for instance in geological formations. This process would be constantly repeated with new biomass, thus reducing the CO_2 concentration in the atmosphere. So far, however, BECCS has barely been tested: there is only one single pilot facility in the US. Moreover, generating the amount of negative emissions that is assumed in climate-economic models would require an additional area for growing biomass that is equivalent to one-and-a-half to two times the surface area of India. Transporting the CO_2 and storing it underground would also require enormous capacities. And yet the use of this technology is always already included in the calculations of climate researchers, environmental NGOs or policymakers when they insist that, based on the IPCC's calculations, targets such as 2 °C or even 1.5 °C can still be met.

Over half a dozen other technological options are also under discussion. They range from apparently unproblematic measures, such as afforestation, to fertilising or liming the oceans. On closer inspection, however, even a universally supported measure such as *afforestation* raises the question of whether it can really help to limit global warming. Especially for the boreal forests of the northern hemisphere, the darkening of the Earth's surface that would result from an afforestation of large regions, and the attending warming effect, might more than cancel out the cooling effect that would result from binding CO_2 in trees – thus achieving the very opposite of the intended outcome. By contrast, suggestions for afforestation of the Sahara or Australian outback simply seem unrealistic.

Fertilising the oceans is based on the idea that algae growth in some maritime regions is limited by a lack of nutrients, especially iron. A targeted addition of iron could provoke algae growth, removing CO_2 from the atmosphere: when the algae die and sink to the seabed, the CO_2 stored in them would be permanently sequestered there. In 2009, the German-Indian iron-fertilisation experiment LOHAFEX attracted international attention to the idea of ocean iron fertilisation. From a climate-policy perspective, however, the results were disappointing. The algae growth primarily caused a local population of crustaceans to multiply. The amount of CO_2 that was removed from the atmosphere was very small.

Another possibility is *liming the oceans*. This involves adding calcium oxide powder (lime) to sea water to increase its pH value. Since water that is more alkaline absorbs more CO_2 from the air, this method could extract carbon dioxide from the atmosphere. At the same time, it could ease the acidification of the oceans. However, the effectiveness of this option is once again questionable: producing calcium oxide powder is a CO_2-intensive process, and transporting it would also generate emissions.

New distributional conflicts

In climate research, at least, the potentials and risks of the individual technological options are now beginning to be explored. By contrast, the political implications of a negative emissions climate policy have not yet been elucidated. The United Nations' (UN) policy to protect the climate has so far relied on allotting differentiated levels of responsibility to individual groups of states that will converge in the long term – at the very latest when all states have reduced their emissions to zero. First, because of their historical responsibility and greater economic capability, the 'old' industrialised nations have to substantially reduce their emissions. Some of them, such as the north-western member states of the EU, have claimed a pioneering status for themselves. Here, the so-called "zero line" – reducing emissions by 100 percent – has been the conceptual reference point. Some EU countries will reach the zero line earlier than others, but member states from Central and Eastern Europe will be obliged to follow suit. This is also true for large emerging economies like China and India. *Convergence towards zero* thus means a pioneering role for a limited period of time. The assumption that such a role will bring positive economic effects rests not least on the idea that the countries initially lagging behind will have to follow suit eventually, and will do so using technologies developed by the pioneers.

However, conceptually expanding the scope of mitigation policy by entering "negative territory" below the zero line – assuming, in other words, that emission reductions of more than 100 percent are possible and worthwhile – could perpetuate the principle of "common but differentiated responsibilities". Should the limit of what is currently conceivable in emissions mitigation be removed, new conflicts about burden sharing would be inevitable. Possibilities for differentiating national climate targets would greatly increase, and the pioneers would have to play their part for much longer. For the year 2100, the IPCC considers net negative emissions of around 10 Gt to be feasible. This would correspond to a global emissions-reduction target of around 125 percent against the base year 1990. If this became a point of reference in the UN climate negotiations, key emitters like China or India, and most of the developing countries would likely argue that the industrialised nations organised in the Organisation for Economic Co-operation and Development (OECD) should continue to take on more far-reaching responsibilities. For instance, emerging economies and developing countries could demand that OECD countries invest more in carbon-dioxide removal whilst they themselves might not even reduce their own emissions to zero. If the EU agrees to a reduction target of, say, 150 percent, we should also expect to see conflicts within the Union: the latecomers from Central and Eastern Europe will be keen to maintain the EU's internal distribution of responsibilities.

Similar conflicts should also be expected between different economic sectors. If BECCS becomes the world's preferred carbon-removal technology, the electricity sector would be the very first to be called upon to generate negative emissions. The sector is already the focal point of emissions- mitigation efforts and is likely to reach the zero line long before the transport or buildings sector.

A necessary strategic decision

Following the IPCC's calculations, carbon removal technologies will have to be deployed extensively if ambitious global climate targets are to be met. This does not mean that climate policy is obliged to go down this path, let alone to the extent discussed above. One could still decide against it. However, under the strictly calculative logic of carbon budgets, this would have consequences for the attainability of global climate targets. Without negative emissions, the 1.5 °C target would be out of reach, and the 2 °C target could only be met at far greater cost, if at all.

If climate policy pioneers like the EU and Germany do not want to prematurely abandon the temperature targets decided in Paris, they will have to start developing strategies for CO_2 removal soon. Global emissions budgets for 1.5 °C and 2 °C will be consumed within five to 20 years. This means that the reduction corridor of 80 to 95 percent by 2050, which is valid for Germany and the EU, can only be an adequate contribution to meeting global temperature targets if emissions in the second half of the century are pushed substantially below the zero line. To date, neither the EU nor Germany has declared itself ready to aim for long-term reduction targets of more than 100 percent. And even if they did, it remains unclear whether such a policy would be technologically and economically feasible, and if it would find sufficient socio-political support.

In principle, a negative-emissions strategy can only be realised if climate, energy and research policy rapidly set the process in motion. Not only would it be necessary to invest substantially in research and development, but also to start a broad political and societal debate, and initiate regulatory considerations. In many respects, these considerations concern challenges that also had to be solved (or still remain to be solved) in deploying conventional emissions-mitigation technologies. For example, precise accounting rules for negative emissions need to be set out, undesired side effects need to be avoided, and specific incentive schemes for using CO_2 removal technologies have to be created. It would seem logical to clarify these points as part of the existing regulatory framework, such as the EU emissions trading directive or the EU's sustainability criteria for biomass.

Politically, the most sensitive issues in any potential German strategy for negative emissions are linked to the fundamental decisions that have already been taken on Germany's energy transition. Would Germany be prepared to rethink its energy transition planning for the electricity sector if BECCS emerged as the technology with the greatest potential at the global level? Would the federal government be willing to change course drastically on biomass and on carbon capture and storage, even at the expense of the decentralised expansion of wind and solar power? Or would it primarily encourage measures whose deployment would barely impact on the structure of the national energy system, such as liming the oceans?

There is still time for a broad discussion on the unconventional forms that an ambitious climate protection policy might take, and for pursuing the corresponding technological options. The longer it takes to open such a debate, the greater is the risk that the Paris climate targets will slip out of reach.

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