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Negative emissions – a positive for climate change

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To achieve the 2°C target agreed in Paris, it is still possible to emit 800 billion tonnes of CO_2 worldwide. At current emissions levels, that corresponds to a period of 20 years. To achieve the 1.5°C target, the budget would be exhausted in under ten years. To make up for previous failed attempts to reduce CO_2 emissions around the world, there is an urgent need to integrate new technologies and approaches. Nearly all models suggest that negative emissions play a significant role in this. They are not only necessary for achieving full carbon neutrality, as there will always be sectors that need to continue emitting greenhouse gases, but they also allow us to repay the CO_2 loan that the Earth has granted us and bring global warming under control.

What are negative emissions?

Processes or technologies that permanently remove greenhouse gases (GHG) from the atmosphere generate negative emissions. These procedures may be based on both biological and technical processes:

- The biological approaches include **natural sinks**. They extract CO_2 from the atmosphere and store it. Typical natural sinks include forests, bogs and the oceans. Forests can trap CO_2 as carbon in wood and in the soil, intact bogs trap GHG by converting organic material into peat, and oceans generate negative CO_2 emissions because plants in the sea use CO_2 to produce biomass. Biological approaches therefore include measures like afforestation, sustainable forest management and bog restoration. These measures are also very good at reducing the impact of climate change by improving air quality or creating a cooler microclimate.

- The **technical approaches** currently focus on research into two technologies: "bio-energy with carbon capture and storage" (BECCS) and "direct air capture and carbon storage" (DACCS). Both technologies are based on the "carbon capture and storage" (CCS) principle. Compared to traditional CCS approaches that reduce the CO_2 emissions when energy is generated from fossil fuels and thus slow the rate at which CO_2 builds up in the atmosphere, these technologies have the advantage of actually reducing the CO_2 content of the atmosphere in the long term.

With **BECCS**, CO_2 is separated out when biomass is burned and it is stored underground. This results in negative emissions because the biomass has absorbed CO_2 from the surrounding air beforehand and it does not release it back into the atmosphere when burned. Instead, it is stored long-term in underground storage facilities. A positive side-effect is that burning biomass generates energy. Supplying the necessary biomass requires either special fast-growing plants or an increase in afforestation initiatives.

DACCS approaches use various chemical and technical processes to filter greenhouse gases out of the air directly. They are also stored underground in the long term. These processes require a lot of energy, meaning that they only generate negative emissions when combined with a supply of energy from renewable sources.

Is the solution a limestone cube the size of the Matterhorn?

Underground CO_2 storage has sparked a discussion on the right geological conditions, similar to the debate about radioactive waste disposal. It requires storage areas that are also suitable for storing natural gas and hydrogen, which results in competition for how they are used. In addition, there are risks of leakage into ground water and the ecosystem. An additional consideration when using BECCS is that achieving gigatonnes of negative emissions requires correspondingly large areas of agricultural land that can be used for biomass. This means that this technology can have an additional impact on local ecosystems and would also reduce the space available for the food industry to grow crops.

Trapping CO_2 within materials offers a potential solution to the problem of storage. The CO_2 that has been extracted through DACCS or BECCS can be used to manufacture polymers that can be processed to make plastics. CO_2 can also be trapped within limestone ($CaCO_3$). Using this method to store annual emissions would generate a cube of limestone with sides around 3,000m long – equivalent to the height of the Matterhorn. So this is not an optimal solution either.

Outlook

The technical approaches (still) hold significant issues so, as a result, FC is currently focusing on natural sinks in particular. Due to the dimensions, the negative emissions these sinks achieve are no alternative to a strict reduction in fossil fuel use. However, they can balance out the unavoidable residual emissions, meaning that they play an essential role in achieving carbon neutrality.■