Why negative CO_2 emission technologies should not be classified as Geoengineering

It is misleading to conflate negative emissions technologies that remove CO_2 from the atmosphere with proposed geoengineering techniques, such as Solar Radiation Management (SRM), as they are fundamentally different.

This conflation downplays the very high risks of geoengineering techniques and disregards viable energy system mitigation options. Geoengineering techniques such as SRM are not a solution to the climate problem.

Negative emissions technologies such as Biomass Energy Carbon Capture and Storage systems (BECCS) could, in principle, be an integral part of the energy-system and will yield net CO_2 removal if deployed, as opposed to CO_2 emissions by fossil-fuel combustion. Negative CO_2 emissions via BECCS can no more be described as geoengineering than the burning of fossil fuels can.

Preventing dangerous interference with the climate system requires solutions that address CO_2 and that are sustainable

Apart from leading to warming, rising CO_2 concentrations are also causing serious damages to the world oceans through ocean acidification. As CO_2 concentration in the atmosphere rises, more CO_2 is absorbed by the oceans, increasing the acidity of the oceans. The effects of acidification have already been observed and will gradually worsen as acidification increases.

Of current anthropogenic CO_2 emissions, about 30% is absorbed by the oceans, in response to the higher CO2 concentration of the atmosphere. The net absorption of CO_2 by the oceans – and hence ocean acidification - will stop when the equilibrium is restored at the ocean's surface. This will only occur gradually after the atmospheric CO_2 concentration ceases to rise and begins to decline. As with meeting the Paris Agreement long term temperature goal, deep reductions of global CO_2 emissions, peaking in the next decade and dropping to zero by 2050 are needed to halt and reverse this.

Geoengineering is not a solution to the climate problem

The lack of appropriate deep emissions reductions to date has led to increased speculation about the use of so-called 'Geoengineering' options. The term 'Geoengineering'[1,2] refers to a range of proposals and, most prominently, to 'Solar Radiation Management' (SRM).[3] SRM techniques do not address the problems posed by increased CO_2 and other greenhouse gas concentrations as a result of anthropogenic emissions and will not deal with ocean acidification. Instead, they aim to reduce only some of the effects of climate change through large-scale technological applications such as stratospheric aerosol particle injection. In this approach, sulfur particles, for example, are injected into the stratosphere, causing a shading

effect and reducing the amount of solar radiation available to warm the lower atmosphere - like a major volcanic explosion, but on a sustained basis. Such an alteration would come with serious adverse consequences and risks including regionally changed precipitation patterns.[4] SRM would not halt ocean warming around Antarctica and would fail to counteract the increasing contribution of Antarctic melt to sea level rise.[5]

If stratospheric aerosol particle injection is stopped, the planet would abruptly warm as GHGs would still have increased. The restoration of the full amount of solar radiation to the lower atmosphere would lead to an abrupt catch up warming effect. These and other considerations led the IPCC's Fifth Assessment Report (AR5) to find clearly that SRM techniques "*entail numerous uncertainties, side effects, risks and shortcomings*" and "*raise questions about costs, risks, governance and ethical implications of development and deployment*". Further, "*SRM would not prevent the CO_2 effects on ecosystems and ocean acidification that are unrelated to warming.*"[6] Other proposed SRM techniques are even less viable and include putting mirrors in space, increasing surface reflectivity of the earth, or altering the amount or characteristics of clouds.

Unlike SRM, some Carbon Dioxide Removal (CDR) techniques such as negative CO_2 emissions technologies address the problem of increased CO_2 concentrations

The term 'geoengineering' is also used to encompass a class of techniques referred to as Carbon Dioxide Removal. Many scientists oppose such a confused,[7] as many (but not all) CDR techniques fundamentally differ from geoengineering proposals such as SRM.

As a consequence of these ambiguities the IPCC's fifth Assessment Report (AR5) was forced to report that "*Some CDR methods fall under the category of geoengineering, though this may not be the case for others*" and that the "*boundary between CDR and mitigation is not clear*."[6] Some CDR techniques such as afforestation or bioenergy and carbon capture and storage directly address the problem of increased CO_2 concentrations,[8] are relatively certain, and have relatively low risks. They are therefore in line with the IPCC's definition of mitigation as *"a human intervention to reduce the sources or enhance the sinks of greenhouse gases."*

Other proposed - but less certain - negative emission technologies include direct-air capture and storage of CO_2, biochar or enhanced weathering that may be part of a portfolio solution of negative emission technologies, but will not provide the scale of negative emissions required. In addition, some CDR proposals clearly qualify as geoengineering proposals such as, for example, ocean fertilisation. The science is clear that ocean fertilisation will not work at the scale required, if at all, while at the same introducing numerous negative side effects related to ocean acidification[9] and de-oxygenation.[10], Ocean fertilisation is also illegal under international law.[11]

Conflating negative CO_2 emissions technologies and techniques such as SRM under the same 'Geoengineering' label is misleading, as it strongly downplays the very high risks of geoengineering techniques, and effectively denigrates viable mitigation options that could be provided by some negative emissions technologies. While large-scale applications of negative emissions technologies could also have negative side effects,[12]the risks related to SRM and negative emissions technologies are not comparable. Sustainable deployment potentials for afforestation or bioenergy and carbon capture and storage have been identified.[12,13]

Known viable negative emissions technologies do not, and cannot, replace the need for early and stringent reductions of CO_2 and other anthropogenic greenhouse gas emissions; Regrettably, negative emission technologies need to be deployed at scale from the 2050's following the early, and rapid deployment of a full portfolio of mitigation options to bring CO_2 emissions to zero globally by around 2050 to achieving the long term temperature goal in the Paris Agreement. Early and rapid reduction of CO_2 emissions are needed now to minimise this need, but cannot eliminate this.

The application of CDR methods in these scenarios - principally afforestation and BECCs - is not a replacement for stringent decarbonisation, but a necessity additional to the rapid reduction to zero CO_2 emissions by 2050.

At this moment, the option that is seen as most likely to achieve large-scale negative emissions combines modern biomass energy systems with carbon capture and storage (BECCS). All elements of this technology are available, and demonstration plants are already functional, and scenarios project very rapid upscaling of this technology in the 2030-2050 period in stringent mitigation pathways consistent with 1.5°C and 2°C. In any case, early and rapid action to reduce emissions in the coming decades is essential.

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