Spotlight
on risk

How could policy address risks from carbon dioxide removal?

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All options for removing CO_2 from the atmosphere and sequestering it for the long term must be assessed for their potential to contribute to reducing climate change risk, but also for their uncertainties, limits and possible adverse impacts.

There are tensions between, on the one hand, the need to deploy carbon dioxide removal (CDR) on a large scale as soon as possible (also considering the uncertainties about the mitigation potentials of the respective approaches) and, on the other hand, the need to anticipate and remediate potential adverse side effects and associated uncertainties, co-benefits, trade-offs and spill-over effects[1]. In particular, the sequestration part of CDR, including issues of scalability, permanence of storage and co-benefits requires careful attention.

Many manifestations of adverse consequences will come from sequestering CO_2 in places where it may not stay long enough, and will be delayed and very diverse. Thus, balancing benefits and risks depends on many factors that interrelate in complex ways, depending to some extent on social and political preferences. Nevertheless, because of upcoming catastrophes caused by climate change, policy decisions are needed now[2].

Discussion about risks associated with CDR, both short-term and long-term, generally concerns the following themes of relevance to policy:

Specificity

Given the large variety of CDR approaches, one must be specific about which technology is assessed. Any generalisation or blanket decision about CDR may lead to wrong, inaccurate or misleading decisions. There are significant variations, even within each broad category of “nature-based” (example: afforestation), “hybrid” (example: bioenergy with carbon capture and storage - BECCS) or “engineered” (example: direct air carbon capture and storage - DACCS).[3]

Assessment

Policy decisions are complicated by the frequent inadequacy or imperfection of current technical instruments for identifying and assessing identified and potential risks. For example, methods for environmental impact assessment (EIA) or life cycle assessment (LCA) would appear to be the instruments of choice, but are currently insufficient to evaluate the impacts of future deployment on a large scale.[4]

Uncertainty

The presence of scientific uncertainty requires using dedicated methods for assessing uncertainty (like the IPCC does) and deciding under uncertainty that are acceptable to society (which often requests large-scale consultation, inclusion and deliberation). Unfortunately, these methods are difficult to use and costly, so, most often, this leads to postponing policy decisions on the motive that “more evidence” would be needed.

Values

There is ambiguity about the present underlying value systems, which support policy decisions, and how those may evolve in the future. In other words, a CDR technique that may present significant risks today may be seen as less risky in the future, or vice-versa. This depends on risk comparison: as the climate changes, related risks will be perceived differently from how they are now. Therefore, risks from CDR will also be perceived differently in the future.

Trade-offs

Making policy decisions about CDR deployment involves looking into environmental concerns and matters of ethics, responsibility, regulation, and liability. Analysis of CDR potential (capacity to remove CO_2), multi-dimensional risks, and co-benefits tend to show that no solution can meet all types of expectations, implying that trade-off resolution is at the core of deciding about deploying specific CDR approaches on a large scale.[5]

Precaution and technical innovation

In the case of promising (yet uncertain) applications, governments are confronted with the need to balance innovation and precaution, both for the short term (present) and the long term (future).

At the technical level, the environmental risks of the various CDR approaches must be assessed with multiple criteria, which can broadly be grouped into two categories: (i) the permanence of storage: risk of saturation, leakage, reversal; and (ii) environmental side-effects of their deployment. Research groups have increasingly studied both.

For illustrative purposes, we cite four research works on CDR risk relevant to policy:

1. Fuss et al. (2018)[6] have produced the first comprehensive review of CDR techniques, including their side effects on the environment and the permanence of the storage (saturation and reversibility). The review established the bases for comprehensive assessments of various CDR approaches.
2. Terlouw et al.[7] have provided a critical review of the life cycle assessment of CDR technologies. The authors present a review of LCAs performed on afforestation and re-forestation, biochar, soil carbon sequestration, enhanced weathering, ocean fertilisation, bioenergy with carbon capture and storage, and direct air carbon capture and storage. They note frequent misinterpretations of LCAs’ outcomes, which should therefore be subject to caution, conclude that more work is needed to understand the environmental implications of CDR deployment, and suggest some areas for improving LCAs to help technicians and policymakers design portfolios of CDR option for the intended purpose.
3. IPCC AR6 WG III[8] has listed and characterised risks and impacts, co-benefits, trade-offs and spill-over effects of CDR methods.
4. A series of publications of the EU-funded GENIE project has specifically addressed risks from CDR techniques.[9]

Recommendations

In the face of challenges of assessing risks from CDR options, particularly those emerging techniques on which there is still little knowledge, policymakers may find it helpful to refer to general governance principles for CDR policy[10], and to the principles of reversibility, robustness and adaptive governance.

- What must be avoided at any cost is **irreversible damage** to the environment or the climate, after which interventions will no longer be possible or effective.[11] When little is known about a threat, but there could be severe negative consequences, precaution-based strategies can ensure the reversibility of critical decisions and resilience-focused strategies increase the system's coping capacity to withstand shocks or adapt to new contextual conditions. Prior to making decisions, policymakers must clearly understand the thresholds of, for example, acceptability or irreversibility. How far can we go before it is too late to act?
- **Robustness** is defined as the ability of decisions to display good enough – though not optimal – performances for various possible futures, such as those that could unfold after adopting emerging CDR technologies. Robustness in decision-making thus reflects the willingness of decision-makers to abandon the advantages of optimisation to gain a higher ability to cope with subjective probabilities (that are revised in light of new information) and generally uncertain futures.[12]
- Finally, **adaptive governance** and regulation could be the most reasonable way to govern and regulate CDR. This approach is particularly needed for emerging and systemic risks presented by CDR. By pursuing a pathway of flexible regulation that can be modified within pre-arranged limits, policymakers and regulators will be able to benefit from new knowledge when it becomes available, and adapt requirements and incentives to avoid unintended adverse consequences and maximise opportunities presented by CDR. Prerequisites for planned adaptive regulation (PAR) include: engaging in multi-stakeholder consultations to determine shared goals; planning for future review and revision of governance arrangements; monitoring of performance and impact of existing arrangements; and funding of targeted research organised in a way that is credibly overseen for quality and relevance and that explicitly feeds into the reassessment of the evidence base[13]. PAR is an effective strategy to avoid lock-in into technologies for which large infrastructure investment must be made, and which would thus be difficult to abandon if evidence shows later that they cause too much environmental damage.

Some of these suggestions follow previous IRGC work on climate engineering[14] and analyses presented in a report published by IRGC in 2020 for the Swiss Federal Office of the Environment[15], and certain conclusions summarised in a spotlight on risk article about "Combatting climate change through a portfolio of approaches"[16]. IRGC will discuss again the topic of CDR risks and environmental sustainability with a forthcoming paper by Benjamin Sovacool and Chad Baum about "Ensuring the environmental sustainability of emerging technologies for carbon dioxide removal".[17]

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[1] Benjamin K. Sovacool, C. M. Baum, and S. Low, *Risk–risk governance in a low-carbon future: Exploring institutional, technological, and behavioral trade-offs in climate geoengineering pathways*. (2022).

[2] For example, see the Swiss Roadmap for the expansion of carbon capture and storage (CCS) and CDR methods, adopted in May 2022.
Full text available on the Swiss Confederation website.
And a summary of the roadmap on the the Swiss Carbon Removal Platform.

[3] See IPCC's categorisation of CDR methods along removal process and timescale of storage, *Cross-chapter Box 8, Figure 1: CDR taxonomy*, in the Working Group III's contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 12: Cross sectoral perspectives, in *Climate change 2022: Mitigation of climate change*. (2022).

[4] Regarding challenges posed by LCA for emerging technologies, see pages 23—26 in IRGC, *Ensuring the environmental sustainability of emerging technologies*. (2022).
Regarding CDR more specifically, see Appendix 1.4, page 49, in the same report.

[5] As explained by the Carnegie Climate Governance Initiative, risk-risk trade-off frameworks are needed to avoid falling into the trap of narrow decision frameworks. See T. Felgenhauer et al., *Solar radiation modification: A risk-risk analysis*. (2022).
Complex multi-risk systems need comprehensive and holistic frameworks for multi-risk decision analysis. See Jonathan B. Wiener, Learning to nanage the nultirisk world, *Risk Analysis*. (March, 2020).

[6] Sabine Fuss et al., *Negative Emissions — Part 2: Costs, Potentials and Side Effects*, (May, 2018).

[7] Tom Terlouw et al., Life cycle assessment of carbon dioxide removal technologies: A critical review, *Energy & Environmental Science* 14, no. 4 (2021).

[8] IPCC AR6 WG III, Technical summary, in *Climate change 2022: Mitigation of climate change*. (2022).

[9] GENIE project, *About*. (accessed November 7, 2022).

[10] For an overview of non-technical and governance principles for CDR policy, see for example
Matthias Honegger et al., The ABC of governance principles for carbon dioxide removal policy, *Frontiers in Climate*. (2022).

[11] For example, when deforestation is such that soils will no longer be able to grow trees.

[12] Cf. Making robust decisions, page 37 in IRGC, *Guidelines for emerging risk governance: Guidance for the governance of unfamiliar risks*. (2015).

[13] Cf. Planned adaptive governance, box 6, page 34 in IRGC, *Guidelines for the governance of systemic risks*. (2018).

[14] IRGC, *Climate engineering* (accessed November 7, 2022).

[15] IRGC, *International governance issues on climate engineering — Information for policymakers*. (2020).

[16] Marie-Valentine Florin, *Combatting climate change through a portfolio of approaches*. (July, 2021).

[17] See IRGC project, *Ensuring the environmental sustainability of emerging technologies*. (accessed November 7, 2022).