



# Communicating carbon removal

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### EDITED BY

Nils Markusson,  
Lancaster University, United Kingdom

### REVIEWED BY

Holly Buck,  
University at Buffalo, United States  
Shinichiro Asayama,  
National Institute for Environmental Studies  
(NIES), Japan

### \*CORRESPONDENCE

Rob Bellamy  
✉ rob.bellamy@manchester.ac.uk

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Rob Bellamy<sup>1\*</sup> and Kaitlin T. Raimi<sup>2</sup>

<sup>1</sup>Department of Geography, University of Manchester, Manchester, United Kingdom, <sup>2</sup>Gerald R. Ford School of Public Policy, University of Michigan, Ann Arbor, MI, United States

Removing carbon dioxide from the atmosphere is “unavoidable” if net zero emissions are to be achieved, and is fast rising up the climate policy agenda. Research, development, demonstration, and deployment of various methods has begun, but technical advances alone will not guarantee a role for them in tackling climate change. For those engrossed in carbon removal debates, it is easy to forget that most people have never heard of these strategies. Public perception of carbon removal is therefore particularly sensitive to framings—the ways in which scientists, entrepreneurs, activists, politicians, the media, and others choose to organize and communicate it. In this perspective, we highlight four aspects of carbon removal for which their framing will play a decisive role in whether—and how—different methods are taken forward. First, the use of analogies can be helpful in guiding mental models, but can also inadvertently imply processes or outcomes that do not apply in the new example. Second, a taxonomic split between “nature-based” and “technological” methods threatens to divert attention from the actual qualities of different methods and constrain our policy options. Third, people are likely to overestimate the emissions-reduction potential of carbon removal, but this misperception can be corrected. Fourth, communications overlook the social arrangements for carbon removal and the alternative trajectories that implementation may take. We end by offering key recommendations for how we can communicate carbon removal more responsibly.

### KEYWORDS

carbon removal, communication, responsible innovation, public perception, framing

## Introduction

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change shows that the remaining carbon budget—the amount of carbon dioxide that can still be emitted while keeping global warming below 1.5 degrees—is almost gone (IPCC, 2021). Removing carbon dioxide that is already in the atmosphere is “unavoidable” if net zero emissions are to be achieved, through accelerating near-term mitigation, counterbalancing residual emissions from hard-to-abate sectors in the mid-term, and achieving net negative emissions in the long term (IPCC, 2022). There are different methods of carbon removal, including those that capture carbon through photosynthesis, such as forestation, biochar, and bioenergy with carbon capture and storage (BECCS); and those that capture carbon through chemical processes, such as direct air carbon capture and storage (DACCS), enhanced weathering, and ocean alkalinity enhancement (Minx et al., 2018). Depending on the capture method, the carbon can then be stored in above ground biomass, soils, geological reservoirs, minerals, or marine sediment and calcifiers.

With research, development, demonstration, and deployment (RDD&D) of various methods having begun in earnest, carbon removal is fast rising up the climate policy agenda. Yet, technical advances alone will not guarantee a role for any given carbon removal method in tackling climate change. They must also have the support of the public. For those engrossed in carbon removal debates, it is easy to forget that most people have never heard of these strategies (Smith et al., 2023). For example, across several countries, fewer than 20% of survey respondents report any prior awareness of carbon removal (Carlisle et al., 2020). This means that unlike concepts (like climate change) for which people already have clear mental models and opinions, carbon removal is still a blank slate.

Public perception of carbon removal is therefore particularly sensitive to framings—the ways in which scientists, entrepreneurs, activists, politicians, the media, and others choose to organize and communicate information about it. Responsible communication of carbon removal requires an awareness of and attention to such framings and the contending interests and uncertainties that underpin them (Bellamy, 2018). It requires that we “unframe” carbon removal by placing it within broader discursive fields to facilitate a robust societal debate about where public support does—and does not—lie (Bellamy and Lezaun, 2017). In this perspective, we highlight four aspects of carbon removal for which their framing will play a decisive role in whether—and how—different methods are ultimately taken forward.

## Framing by analogy

One way of helping people make sense of carbon removal is by using analogies or metaphors to create guiding mental models to understand new concepts (Castree, 2020). In lieu of other information, analogies and metaphors can shape public perceptions of how carbon removal methods work, as well as their benefits, risks, and trade-offs. While analogies are vital education tools, they can also inadvertently imply processes or outcomes that do not apply in the new example (Raimi et al., 2017).

For example, describing DACCS as like “giant fans” may convey some aspects of the process and energy required for this technology, but does not convey the need to transport captured carbon. On the other hand, describing DACCS as working like “artificial trees” may convey the idea of storing carbon through this process, but doesn’t instill understanding of the energy required. Thus, communicators must carefully employ analogies and metaphors that accurately convey key processes of carbon removal, avoid those that could create misunderstandings, and clearly delineate how carbon removal both is and is not like these example phenomena.

## The nature framing

There is a taxonomic split in some carbon removal communications between “natural” or “nature-based” and “technological” methods. This has significant implications for public acceptance, as people are well known to prefer natural-seeming actions over unnatural ones (Sjöberg, 2000). Contrary to widely held assumptions, however, what constitutes a “natural”

method of carbon removal is not self-evident, but is selected by people acting in social groups (Bellamy and Osaka, 2020). Nature is universal, encapsulating the physical world in its entirety, including untouched nature, nature modified by humans, and humans themselves. Thus, any efforts to establish some subset of nature as the “one true nature” are unavoidably exclusionary. Such exclusions are apparent in some carbon removal communications, where things manufactured from nature (e.g., DACCS) are typically excluded from the “natural” category, as are enhancements of relatively untouched natures, such as the oceans (e.g., ocean alkalinity enhancement), and enhancements of nature modified by humans, such as agriculture (e.g., enhanced weathering). In one particularly inconsistent example, BECCS and biochar both involve enhancing an existing natural process (biomass growth) and things manufactured from nature (power stations and pyrolysis plants, respectively), but only the latter is deemed “natural.”

Armed with this knowledge, carbon removal communicators have two choices. One choice is to (cynically) capitalize on the power of the nature framing and give a significant boost to perceptions of their preferred methods. The danger here is twofold. First, attention may be diverted from the actual qualities of a method and substituted with a general sense of “goodness,” subjecting the methods to lower standards of approval (Osaka et al., 2021). Second, the appeal of nature, combined with a restricted set of methods, constrains what are considered desirable, fundable, and implementable policy options. The other choice would be to acknowledge the politics and dangers of the nature framing and either stress the “nature” in all carbon removal methods (Bellamy and Osaka, 2020); stress the “technology” in so-called “natural” carbon removal methods (Markusson, 2022); or better still, avoid the label altogether and instead refer to specific methods and/or use scientific terminology (Osaka et al., 2021). Either way, all carbon removal methods would be evaluated on an equal footing, rather than some benefiting from the label and others not.

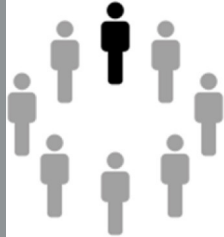
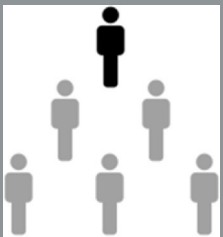
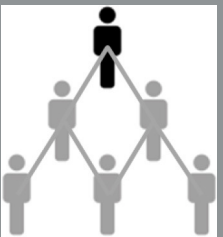
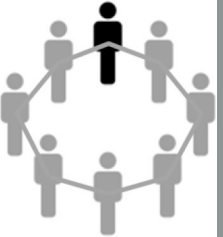
## The moral hazard framing

Climate advocates often fear that discussion of carbon removal will deter from the need for emissions reductions in general (Lenzi et al., 2018), or specifically for fossil fuel emissions through offsetting<sup>1</sup> or residual emissions that are deemed too costly or hard-to-abate.<sup>2</sup> This could happen either at the level of individual people’s judgements or at the institutional or societal level (Jebari et al., 2021). Some empirical evidence suggest that this “moral hazard” effect can occur at the individual level for some forms of carbon removal (Hart et al., 2022); however, these effects are small and do not emerge for all forms of carbon removal (i.e., reforestation). Experiments find that information about carbon

1 Carbon removal could be used for offsetting but is not the same as offsetting (see Allen et al., 2020).

2 Typically cited hard-to-abate sectors include aviation, shipping, concrete production and agriculture, but there is significant ambiguity around the meaning of residual emissions and what should and should not count as such (see Lund et al., 2023).

TABLE 1 Four ideal-typical implementation contexts for carbon removal (after Rayner, 1991; Bellamy, 2018; Halik et al., 2018).

	 Entrepreneurial carbon removal	 Opportunistic carbon removal	 Governmental carbon removal	 Community carbon removal
<b>Value of carbon removal</b>	A means to generate equal opportunities for wealth and prosperity	A means to enhance personal financial and social power	A means to maintain stability for the governing system	A means to secure equal social outcomes for group members
<b>Regime of carbon removal</b>	A bottom-up regime of private organizations or individuals employing a laissez-faire style	A personalized, top-down regime employing an intimidating style	A centralized, top-down regime employing a regulatory style	A bottom-up, community-based regime employing a preventative style
<b>Policies of carbon removal</b>	Fiscal incentives and RDD&D support to facilitate individual decisions	Personal, idiosyncratic rules derived from strongman rule	Command and control and incentive regulation from government	Command and control regulation and information derived from consensus
<b>Evaluation of carbon removal</b>	Focused on economic growth and individual liberty, with compliance through the market system	Focussed on maintenance or expansion of power, with compliance forced on rivals	Focussed on functional standards, with compliance imposed by 'best available science'	Focused on equality of outcomes and ecological condition, with self-compliance by community members

removal and solar geoengineering can variously reduce emissions-reductions support, increase it, or have no effect either way (Raimi, 2021).

Furthermore, there is reason to think that this too is the result of framing. People are notoriously bad at estimating the effects of emissions-reducing activities (Larrick et al., 2015), and thus likely to overestimate the emissions-reduction potential of carbon removal. But these misperceptions can be corrected. For solar geoengineering, moral hazard effects disappear when people are correctly told that these technologies are not a silver bullet (Raimi et al., 2019). Parallel research finds that interventions promoting individual-level climate behaviors can crowd out policy support when people overestimate their emission-reducing potential, but this effect disappears when these misperceptions are corrected (Hagmann et al., 2019).

Thus, policymakers need not avoid carbon removal because of a fear that it will inevitably crowd out public support for emission reductions. Instead, communicators must clearly explain to the public that while carbon removal may help reach climate goals, it can only do so on the margins of substantial emissions reductions. When possible, putting the extent of the carbon removal potential in comparison to the potential for emissions reductions from actions like shifting to renewable energy may help keep people from falling prey to moral hazard effects.

## Framing implementation

Communications on carbon removal—and indeed research on public perceptions of carbon removal—overwhelmingly focus on the technical characteristics (and societal responses to those characteristics) of carbon removal: the trees of

forestation, the “giant fans” of DACCS, or the fine-grained rock of enhanced weathering, and so on. But carbon removal methods are not simply technical objects, they are combinations of technical objects and social arrangements that work together as a single system. Carbon removal methods simply will not work without an implementation context: purposes, people, institutions, policies, politics, procedures, and so on. In other words, the implementation of carbon removal is only being half-framed. And early empirical work shows that the missing half of carbon removal communications can make all the difference in terms of public support. The policy instruments chosen to incentivize BECCS, for example, can significantly change the way people perceive the technology itself (Bellamy et al., 2019).

Crucially, the implementation contexts for carbon removal are not yet written. “Upstream” of significant RDD&D we can—and should—explicate the alternative trajectories that the implementation of carbon removal methods may take. To illustrate, Table 1 describes four very different possible implementation contexts derived from cultural theory. For example, the value of carbon removal does not lie only in its capacity to help stabilize climate and society; it is also an opportunity to generate prosperity, personal power, or more equal outcomes. Carbon removal need not be implemented in a centralized, regulatory regime; it could instead be private and laissez-faire, idiosyncratic and intimidating, or community-based and preventative. The policies of carbon removal need not be driven by government; they could facilitate individual decisions, or be derived through strongman rule, or group consensus. The evaluation of carbon removal does not only concern functional standards; it also concerns liberty and economic growth, the maintenance or expansion of power, and social equality and ecological condition.

The task for carbon removal communicators then is to not presume a particular implementation context, but to articulate such alternative pathways. Who does the communicating is also important: messengers should be those with identities or styles of argumentation that do not imbue communications with a meaning of conflict between identifiable social groups (Kahan, 2012). In this way, people of different social groups are more likely to view information in an open-minded way.

## Conclusion and recommendations

The public's lack of knowledge makes them beholden to the agenda of their communicators, whether that is to fund carbon removal RDD&D, to fight against its inclusion in portfolios of climate action, or to use carbon removal to justify lackluster emissions-reductions. With this great power of persuasion comes great responsibility; communicators must consider how their attempts to inform may be biased by their own opinion, as well as how other communicators may be building the case for alternative frames of carbon removal.

Public support for carbon removal will hinge on responsible explanations by communicators who are aware of and attend to different framings. In particular, there must be reflection on the analogies and examples chosen to make sense of carbon removal methods which remain unfamiliar to a great many people. There must be reflection on whether to invoke nature to describe particular methods. There must be reflection on how to situate carbon removal methods in relation to emissions reductions. And there must be reflection on the different possible implementation contexts for carbon removal. To help engender more responsible communications around carbon removal, we offer four recommendations to scientists, entrepreneurs, activists, politicians, the media, and others:

1. Inform the public about carbon removal using clear language and analogies but make clear how it differs from these existing processes.
2. Avoid framing carbon removal methods as “nature-based” or “natural” and instead refer to specific methods and/or use scientific terminology.

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3. Stress that carbon removal is not a substitute for necessary and urgent emissions reductions: reductions first, removals second.
  4. Communicate the social arrangements of carbon removal as well as the technical objects; articulating the alternative trajectories that carbon removal implementation could take.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

RB and KR contributed equally to the conception and writing of the article. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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