10

CARBON REMOVAL AND THE DANGERS OF EXTRACTIVISM

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Introduction

Climate change is many things. A predominant but incomplete way to think about climate change is that it is the problem of an overconcentration of greenhouse gases in the atmosphere. Responding to climate change is, from this starting point, about cleaning up energy, transportation, and food systems to limit the emission of additional greenhouse gas molecules.

In recent years, climate models meant to help policymakers to understand the greenhouse gas concentration implications of policy choices have been indicating that emissions reductions alone are likely not enough to keep global warming from crashing through dangerous temperature thresholds. This insight has driven a growing cadre of scientists and policymakers to exhort the need for, in addition to greenhouse gas emissions abatement, the *removal* of carbon dioxide from the atmosphere. Carbon removal (also sometimes termed carbon dioxide removal, greenhouse gas removal, or negative emissions technologies of approaches) refers to a set of current or imagined technologies and land and ocean management practices that could pull vast amounts of carbon dioxide out of the atmosphere. The idea is to take carbon dioxide into long-term storage or direct it to beneficial use, lessening the atmospheric concentration of this most important greenhouse gas (Morrow *et al.*, 2018).

In this chapter I consider how carbon removal has found its way into the international climate response conversation and the dangers inherent in carbon removal done badly. This is a story of the interplay between computer-based climate models and policy development. Some of the discussion below gets a bit technical, looking at the ins and outs of how carbon removal has come to be seen as an essential part of international climate change response based on the workings of climate models. The basic message, though, is straightforward. Computer-based models are a sophisticated tool to help us peer into plausible futures. The models

themselves and the uses to which they are put, though, have quirks, some of which have to do with the assumptions upon which they are based. I show below how an *extractivist* orientation is present in the models in ways that shape the results the models display and the policy conversations that the models facilitate. The chapter unpacks how extractivism is at play and how it might be guarded against in future consideration of carbon removal options.

The conceptual leaping-off point for the chapter is, then, “extraction.” The term extraction connotes a set of processes whereby materials are taken from the earth and put to human use. Extraction in itself is a neutral notion. All individual members of all species make use of the world around them. Biological systems operate via flows of nutrients. Solar energy is converted into biologically available chemical energy through photosynthesis and the material wastes generated by one individual or species are utilized as inputs by other individuals or species, resulting in great chains of biological connectedness (McDonough and Braungart, 2002). Non-biological systems on earth similarly operate in cycles—think carbon or nitrogen or water cycles—such that the extraction of materials and the passing of materials through different bodies and states is very much the natural order. By this reckoning, the fact that human beings engage in extractive processes is not necessarily a harmful or problematic thing in environmental terms.

“Extractivism,” by contrast, connotes a logic. Though extraction can be considered a neutral set of processes and practices, modern-day human beings tend not to extract in the manner of other species. Instead, our economies, societies, and individual lifestyles depend on the extraction and utilization of materials in ways and at scales that distort, disturb, and often destroy natural processes. An extractivist mindset or pervading set of understandings opens the whole world to human exploitation, justifying taking with too little regard for the environmental and social consequences.

Such a logic informs not just traditional extractive processes and industries—mining of minerals and fossil fuels, taking of timber and other products from the world’s forests, removal of fish from the world’s oceans, and the like. In addition, in these early days of the Anthropocene, the logic of extractivism can be discerned in a much wider variety of human practices. As John-Andrew McNeish and Judith Shapiro point out in this volume’s Introduction, an extractivist logic serves to justify the violence of removal and exploitation that are hallmarks of our present hyper-extractive age, noting further that green technologies and other contemporary efforts to tackle environmental ills can themselves depend on the continuance of social exploitation and the contaminating practices of non-renewable extraction.

What, then, of carbon removal? Carbon removal can be viewed, in a positive light, as potentially righting a prior extractive wrong. By this reckoning, carbon removal could operate as a kind of *de*-extraction, allowing the carbon pollution associated with the earlier mining of oil, gas, and coal deposits or the plundering of the world’s soils and forests to be pulled from the atmosphere, where in large quantities it poses dangers to all life, and returned to underground reservoirs or placed in other forms of safe storage. This understanding of carbon removal is

apparent in what some call carbon removal approaches “negative emissions technologies”—a reversal of prior emissions ills.

I hold the position that carbon removal must now be considered a necessary component of climate change response. I have been convinced, by the scientific assessments that I examine with something of a critical eye in this chapter, that carbon removal must now be a major component of humanity’s responding effectively to climate change, and my research and public policy group, the Institute for Carbon Removal Law and Policy, aims to assess and advocate for sustainable approaches to carbon removal. However—if carbon removal is undertaken according to an extractivist logic or if the promise or practice of carbon removal are used to perpetuate reliance on extractivist ways of being, this could have dire consequences. Carbon removal, even if it is countering past extractive undertakings, can be an extractivist activity like any other. Much depends on how carbon removal as an enterprise is understood and how particular forms of carbon removal are ushered into being.

The development and deployment of large-scale carbon removal options is now being touted in mainstream climate change response quarters as essential. Yet as my colleague David Morrow would say, even if carbon removal is important, not all forms of carbon removal are created equal. Some forms of carbon removal utilized in particular ways will be needed and will be beneficial for people and the planet. Others, though, could entrench or perpetuate the very social processes that are driving climate change. Carbon removal, if poorly considered or poorly implemented, could worsen rather than combat the very problem that it is designed to address.

Climate change is about concentrations of greenhouse gases in the atmosphere. It is also, though, about much else besides. It is about the social, political, and economic arrangements that have driven carbon from terrestrial storage into the atmosphere. It is about the systems of belief and understanding that mediate humanity’s collective relationship with the other-than-human world. And it must fundamentally be about the environmental and social implications of efforts to respond. Climate change, said differently, is not just a technical problem amenable to straightforward technical answers. A focus on extractivist logics reminds and teaches us that climate change is a complex *social* challenge. Responding to climate change requires the best of us, not just in terms of ingenuity applied to development of technical responses but in terms of how people, other species, and places are attended to in efforts to comprehend climate change and in the actions taken to address it.

The chapter is organized as follows. The next section offers a brief overview of what is meant by carbon removal and how the consideration of carbon removal has gained traction in the space of a handful of recent years. Then, we dig more deeply into the workings of climate models—and particularly integrated assessment models (IAMs)—to look at how an extractivist logic is already at play in the scientific and policy assessment of carbon removal options. We follow by considering what it will take to guard against an extractivist carbon removal. We then provide a brief conclusion.

What is Carbon Removal?

The idea of removing carbon from the atmosphere and putting it into storage has been a part of the international policy consideration of climate action since its earliest days (Carton *et al.*, 2020). Augmentation and protection of forests for the role they play as carbon sinks is captured via the Reducing Emissions from Deforestation and Forest Degradation (REDD+) platform. Soil carbon sinks have long been a focus of land use analyses and were pushed as an important component of climate change response by the French government during its hosting of the 2015 United Nations Framework Convention on Climate Change conference of the parties.

In more recent years, the international carbon removal conversation has moved far beyond consideration of such “natural” carbon repositories. The impetus for an expansion of what is needed from carbon removal and the options available for carbon removal has come from two main quarters. First, a range of recent scientific assessments based principally on computer-based climate models, discussed in more detail below, have suggested the need for staggering amounts of carbon drawdown to prevent the crossing of critical temperature thresholds. Second, new potential opportunities for carbon removal have emerged because of scientific and engineering investigations that posit chemical or technological pathways for the removal and storage of atmospheric carbon.

BOX 10.1 FORMS OF CARBON REMOVAL

There are a wide variety of potential ways to draw carbon dioxide down from the atmosphere and direct it to storage or put it to use. The acronym for this expanding field is CCUS, for “carbon capture, utilization, and storage,” indicating a two-step process: 1) Capture carbon dioxide from the atmosphere; and 2) Do something with the captured carbon dioxide to prevent it from reentering the atmosphere.

When it comes to step 1 (the carbon capture step), it is helpful to think of a spectrum of options. At one end of the spectrum is a set of biological pathways to carbon drawdown—carbon dioxide pulled down into growing trees, plant and microbial material in soils, or life growing in oceanic ecosystems. At the other end are chemical or engineered pathways—direct air capture (using a chemical membrane and mechanical systems to separate carbon dioxide directly from the open air) and enhanced mineralization or enhanced weathering (grinding and spreading certain minerals to speed the process by which atmospheric carbon finds its way into rock formations). In the middle, between these two poles, is bioenergy with carbon capture and storage (BECCS). BECCS involves growing biomass as a way to pull carbon dioxide out of the atmosphere, turning the biomass into a liquid fuel or burning it directly, and then capturing the carbon dioxide released during combustion.

For step 2, the carbon storage or utilization step, there is again an array of options. The fully biological approaches store carbon in biological systems,

turning carbon into the stuff of trees or seagrasses or soil deposits. There is vast potential for additional carbon storage by these “natural climate solutions,” as some call them. Carbon held in biological systems, though, must be monitored and governed closely to avoid return to the atmosphere. Forest fires, farmers deciding to once again plough their fields, or the destruction of coastal ecosystems can all release stored carbon.

Engineered carbon removal approaches and BECCS can store carbon by having the carbon dioxide rendered into a liquid form and then pumping the liquid underground into so-called “legacy” oil and gas wells (places from which some or a majority of oil and gas has already been removed) or natural rock formations. The idea is then to trap the carbon dioxide underground for decades or centuries. Enhanced weathering offers still another route to carbon storage, aiming to hold carbon in solid mineral deposits.

There are also ways to utilize captured carbon dioxide. One company, Carbon Engineering, for instance, is using direct air capture to pull carbon dioxide from the atmosphere and is then converting the captured carbon into a liquid fuel. Across the full lifecycle of the fuel much less carbon dioxide finds its way into the atmosphere per unit of energy. This approach reduces flows of carbon dioxide into the atmosphere but, importantly, does not potentially lessen atmospheric concentrations in the same way as underground or biological storage, meaning that those kinds of uses are not really “negative emissions technologies.” Taking carbon dioxide into long-lived products like cement, meanwhile, is a use that is more analogous to long term underground storage methods.

Let us look in turn at the two main drivers of an expanded role for carbon removal in climate response. On the first point—that authoritative reports have been making the case that carbon removal will be essential to avoid dangerous climate futures—a pair of reports from the Intergovernmental Panel on Climate Change (IPCC) are most telling and have had the most impact. The IPCC’s Fifth Assessment Report (AR5), released in 2014, indicated, by way of climate modeling, the likely need to draw down billions of tons of carbon dioxide by 2100, ratcheting up rapidly from 2050, to have a good chance of staying beneath a 2°C threshold of warming above pre-industrial averages (Intergovernmental Panel on Climate Change, 2014). Mid-range estimates from the report suggested a need to remove 670 billion metric tons (Gt) of carbon dioxide during this century. The implication is that something like 10 Gt of carbon dioxide or more would need to be removed each year by century’s end. To put this into perspective, all current global anthropogenic emissions of carbon dioxide amount to about 40 Gt per year. The scale at which carbon removal is now being contemplated is simply gargantuan.

The more recent IPCC special report on 1.5°C (noting that 1.5°C is the aspirational target from the Paris Agreement) featured a recalculation of the global carbon budget, suggesting a slightly expanded window for climate action and the

potential for traditional emissions abatement activities alone to be enough to keep warming below 2°C (Intergovernmental Panel on Climate Change, 2018). Still, the report suggests that the more ambitious 1.5°C target appears, according to the models, to be almost impossible to reach without the utilization of massive amounts of carbon removal.

These kinds of scientific assessments, based on climate models and scenario-based projections of human actions under conditions of climate change, have shifted the conversation about carbon removal. Carbon removal used to hover on the fringes of the climate change response conversation. Biological carbon removal pathways were seen as useful augmentations to efforts to keep greenhouse gases from entering the atmosphere and technological carbon removal approaches were seen as overly costly or unable to be scaled. Now, biological carbon removal and, in a widening set of circles, technological and engineered carbon removal options are being talked about in the same breath as emissions abatement, with carbon removal now being looked at either as a form of climate change mitigation or at the very least as something that will be critically important alongside traditional climate change response activities (Lomax *et al.*, 2015; Waller *et al.*, 2020). This shifting dynamic is captured and was foreshadowed in the Paris Agreement's call, in Article 4, for a balancing of greenhouse emissions from sources and capture by sinks by mid-century.¹

The climate models have made clear that carbon removal will be needed. Much hinges, then, on *how* carbon removal appears in the climate models and how those models themselves serve as a guide to social and political consideration of climate change and climate change response options. As it stands, representation of carbon removal in climate models and the broader climate modeling universe itself have problematic dimensions that need to be unpacked. The links between the structure of model-informed scientific assessments and an extractivist logic are explored in the section that immediately follows.

On the second point noted above—the fact that scientists and engineers have now posited a wide array of possible modes of carbon removal that go far beyond forest and soil sinks—there are a couple of things to call attention to.

The first is that there is a proliferating array of potential options for large-scale carbon removal. Some, like forests and soil sinks, are reasonably well understood in their basic technical elements, though there are still big estimate ranges even for these more established pathways and much still to learn about whether and how such options can be scaled to provide a meaningful contribution to the levels of carbon removal called for in the models and reports referenced above. Some of the more speculative chemical or engineered forms of carbon response – options like direct air capture with carbon storage or enhanced weathering (also known as enhanced mineralization) (see Box 10.1 above)—seem to offer large potential for carbon removal and storage, but have an array of potential risks or current cost impediments that again makes unclear the potential scalability of the approaches (Fuss *et al.*, 2018).

The second is that all forms of carbon removal currently being discussed would take a good deal of time, effort, and money to develop, and would only operate over very long timescales to bring down atmospheric levels of carbon or to offset the emissions from hard-to-mitigate societal activities. Carbon removal is almost certainly still needed, but I point out these challenges to make clear that carbon removal cannot be seen as any kind of *replacement* for emissions abatement. Crucially, it is also not clear how receptive people would be to the land use changes that, say, massive BECCS operations would entail, or the pipelines needed to move captured carbon dioxide to storage locations that would accompany development of direct air capture facilities, or the potential negative implications for human and environmental health entailed by grinding up and spreading minerals for enhanced weathering. Technical response options are also social and political responses, in that there will be contestation over various pathways and projects, and there are myriad different ways to do something like BECCS or direct air capture, producing differing environmental and social impacts and differing constellations of winners and losers. So while climate models tend to give some time for the bringing online of large-scale carbon removal—the currently accepted wisdom is that carbon removal will have to be scaled up over the second half of the century—there is in fact some urgency associated with the investigation of carbon removal, to see whether or not any of the contemplated options can pan out and to make sure that carbon removal plans proceed along socially and environmentally desirable paths.

The phrase “pan out” obscures a lot. Most of the analyses to this point of carbon removal options have focused on absolute or relative cost and technical potential and have paid too-little attention to social dimensions. In the concluding section of the chapter I will turn back to consider the kinds of analyses of carbon removal needed now to escape the trap of an extractivist logic.

Carbon Removal and the IPCC: Extractivism in the Climate Models

The above section indicated that the mainstreaming of carbon removal has come largely on the back of assessments of climate futures derived from computer models. In this section I consider how carbon removal has emerged from recent authoritative reports and how the computer models themselves operate to shape the consideration of carbon removal alongside other forms of climate change response. A big piece of the story has to do with the structure of the scenarios that undergird modern climate change computer modeling, and especially the assumptions that are captured in those scenarios. What we’ll see by way of a shallow dive into climate modeling is the extent to which an extractivist logic is transported into climate models, and particularly the IAMs that are the backbone of climate change projections, via a set of underlying assumptions about societal futures.

Climate modeling is something of an arcane and opaque endeavor. Some of this has to do with the nature of the enterprise itself. The work of climate modeling is technical and highly specialized. This makes it hard for non-experts to discern how climate modelers do their work and, moreover, how to fully and robustly interpret

the results of that work. Climate modelers also tend to operate in tight teams around tight projects (although there is much collaboration between and among teams), while facing a set of professional pressures to make their results politically and socially relevant. Yet given the importance of climate models in policy and broader consideration of what climate change is, what it means, and how to respond to it, peeking behind the climate modeling veil is an important exercise.

The focus here is IAMs. They are the backbone of model-based analysis of the social dimensions of climate change. They are “integrated” in the sense that they bring together different modules that represent energy systems, the land sector, typically a simplified representation of the climate system (simplified as compared to massive Earth System Models that aim for much more complete representation of the climate), and other physical and social systems of interest to researchers. The characterization here is a little loose because there are a number of different major IAMs that operate in slightly different ways. Of most interest to what follows is that the major integrated assessment modeling teams have come together around a common scenario architecture, described in more detail below, and operate according to a range of common assumptions.

Scenarios have been basic to consideration of climate response for decades. The kinds of scenarios that are captured by modern IAMs can be called “exploratory scenarios”, in that they are designed to indicate in a systematic fashion an array of potential and plausible futures, as a tool for scientific assessment and policy development (Nikoleris *et al.*, 2017). Scenarios are imperfect tools, however. Any scenarios, climate scenarios included, are open to an obvious line of attack: it is really hard to predict the future. Those who work with scenarios seek to guard against such criticisms by asserting that scenarios are images of the future that do not seek to be either *projections* or *forecasts*. The scenarios played out in computer-based simulations are meant to guide interrogation of possible futures, not to act as perfect representations or foretellings of those futures.

However, despite those much-repeated caveats, it is easy to *read* the outputs of IAMs as concrete representations of the future. Model outputs lead to numbers and graphs in authoritative reports stamped with the imprimatur of science, such that when a model output reports, “based on a whole bunch of assumptions about how the world works and how the future might pan out it sure looks like we are going to need a lot of carbon removal,” it can look like what the model is conveying is, “carbon removal is now essential for climate change response.” The difference is subtle but it is important, particularly given the ways that climate modeling and policy development operate in a kind of paired dance, as described in more detail below.

The state of the mainstream integrated assessment modeling art is informed and is captured in the IPCC’s AR5 and Special Report on 1.5°C, along with the scoping work already underway for the sixth assessment report (AR6). I will focus here particularly on AR5. In advance of AR5, a collection of modelers set about determining two different linked scenarios to replace the earlier “SRES” (Special Report on Emissions Scenarios) scenario pathways. The two different elements of this new scenarios architecture are as follows:

1. The “representative concentration pathways” (RCPs) originally spanning four different possible greenhouse gas concentration futures and their concomitant radiative forcings (that is, factors that alter the amount of the sun’s energy absorbed by the Earth or the atmosphere); and
2. The “shared socioeconomic pathways” (SSPs) offer five different packets of socioeconomic factors—population, economic growth, education, urbanization, and generalized rates of technological development—indicating how the social world might evolve in the absence of climate policy.

Together, the RCPs and SSPs now constitute an agreed-upon set of starting points for the work of the major IAM modeling teams that provide input into the IPCC processes (van Vuuren *et al.*, 2014). The RCPs offer projections of how greenhouse gas concentrations might grow across this century and what that could mean for average levels of atmospheric warming by century’s end. The SSPs then describe a range of different socially defined present and future conditions, with the understanding that each of those futures drives innately towards higher or lower greenhouse gas concentrations even in the absence of policies designed to respond to climate change. The SSPs and RCPs are meant to operate together in the work of the modeling teams, so that a given scenario will show how a particular RCP is generated from a particular SSP. That is, the modeling teams are able to use this architecture to ask, can I get my model to produce a certain amount of warming by the end of the century (the RCP component) based on a particular set of social conditions as a starting point (the SSP component)?

To provide more clarity, let’s now bring carbon removal into the picture. The RCP2.6 scenario is the “low radiative forcings (that is, relatively low climate change) by the end of the century” pathway that, in model runs, offers the best chance of keeping atmospheric temperatures beneath 2°C. In order to achieve the RCP2.6 pathway, the vast majority of model runs that were reported in IPCC AR5 utilized carbon removal (or “negative emissions”) at vast quantities by mid-century.

If all of that seems a bit technical and arcane, that is because it is. At the same time, it is an immensely important result. It was this finding that drove carbon removal firmly onto the international climate change response agenda. For some critics, though, this was a case of, as Matthew Nisbet has put it, “legitimizing the unbelievable” (Nisbet, 2019). Carbon removal options at the kinds of scales called for in AR5 do not exist and might never exist. The model results say that large scale carbon removal is needed, but no such large-scale carbon removal might ever materialize. This has led the IPCC to be accused of inadvertently or willfully justifying rounds of political target-setting followed by inaction. The international community agreed to act to limit warming to 2°C (and more recently, via the Paris Agreement, to aim to limit warming to no more than 1.5°C); the IAMs then showed that the target is possible, so long as there is reliance on an imagined set of possible future technologies and land and oceanic management options. This gives rise to what Oliver Geden has called “magical thinking” out of the IAMs—where the models appear to promise a magical fix for climate change and the policy community willingly reaches for it (Geden, 2015).

An additional dynamic was at play in AR5. In the IAMs only two negative emissions options were present—afforestation/reforestation and BECCS. The upshot is that it was not carbon removal as a big suite of potential options that were shown to be needed by the IAMs, but rather the models could be read as suggesting that massive amounts of afforestation and BECCS would be essential to meeting temperature targets.

BECCS, at the scales called for in the models, if it were to do alone all of the carbon removal work that the models are calling for, would require up to twice the land area of India to be planted in new agricultural feedstocks; would require a new pipeline and transportation infrastructure at least as big as the current global oil, natural gas, and coal infrastructure to move carbon dioxide from point of capture to point of sequestration; and would in a variety of other ways amount to a massive agricultural and industrial undertaking with associated social and environmental impacts (Burns and Nicholson, 2017). The IAMs suggested that large-scale BECCS would be needed. But physics, biology, and the operation of the social world suggest that large-scale BECCS (or, at least, BECCS at the scale suggested in the climate models) is almost certainly not possible.

It was widely reported out of AR5 that BECCS would be needed to save the world (or some variant). The modelers intended no such message through their summarizing of model results. Instead, BECCS was a stand-in in the models for a whole potential suite of carbon removal options. Moreover, BECCS arose from the models out of a set of assumptions that *bake in an extractivist logic*. The assumptions captured in the RCPs and now (for AR6) in the RCP and SSP architecture *assume that the social world is basically going to carry on as it is now*. There are big differences, to be sure, between SSP1 (an imagined “sustainability” world where there has been some embrace of lower consumption pathways and greener tech) and, say, SSP3 (an imagined “regional rivalry” world where countries retreat into nationalistic or bloc positions and there is low international appetite for environmental action) (O’Neill *et al.*, 2017). All of the scenarios, though, turn on quite simple relationships between a very short list of variables. The variables are also conservative in the sense that they do not vary a great deal from the world of today. Even SSP1, the “sustainability” world, has increasing GDP through the end of the century and a set of additional assumptions that make it incompatible with, say, a de-growth reading of sustainability or a sustainability premised on something other than what Jennifer Clapp and Peter Dauvergne have characterized as “market liberal” environmentalism (Clapp and Dauvergne, 2011).

The IAMs, in turn, do not factor in the potential for big sudden changes, for big surprises, for massive positive or destabilizing social, economic, political, or technological shocks. They look, instead, to produce useful representations of plausible futures extrapolated in a linear fashion across a narrow range of variables. This means that when the models report that BECCS is needed at large scales to keep warming beneath 2°C, what the models are really saying is that in their very narrow and flawed representations of the world, the limited toolkit available to the models requires utilization of BECCS to reach the temperature target determined by policymakers.

The previous sentence sounds harsh. It is not meant to. All models are narrow and flawed representations of the world. The IAMs are incredibly useful as one way to explore climate futures. That said, we should always be cognizant that because the IAMs basically work with straight-line extrapolations from the world as it is today, they bake in core features of the present world. They bake in features of the global economy and technological development, for instance, making it appear that these features will be stable and consistent moving forward. Because there is no room for discontinuities or abrupt changes, an extractivist logic is at work in the IAMs, just as it is in the present hyper-extractive real world. What I mean by this is that the IAMs, working now from the RCP + SSP architecture, assume a set of relatively stable relationships that hold the current world intact. In such a world, when the global political economy cannot undergo radical change, when societies cannot experience sudden and far-reaching values shifts, and political power relations are hard and fast, the models struggle to represent worlds with limited temperature increase absent carbon removal.

Escaping an Extractivist Logic

The scenarios utilized by the IPCC and other scientific assessments of climate change are immensely important. They help, as Edward Parson has put it, to “make ... required speculation more disciplined” by making more explicit the underlying assumptions about economic and other social processes (Parson, 2008). However, the mainstreaming of carbon removal into the climate change response conversation points to some ways in which the influence of climate models on policy processes can be problematic.

One thing that has happened with the mainstreaming of carbon removal is that policy incentives have started to be developed in some places to encourage research and development. In the United States, for instance, a number of different federal policy instruments have been advanced, among them the 45Q tax credit and the USE IT Act.

The 45Q tax credit provides an incentive to store captured carbon geologically. As it currently operates, the provision in the U.S. tax code offers \$20 per ton (increasing over 10 years to \$50 per ton) for carbon pulled from the atmosphere and sequestered in saline aquifers. In addition, and importantly, the provision offers \$10 per ton (increasing over 10 years to \$35 per ton) for carbon dioxide that is injected underground in support of what is known as “enhanced oil recovery” (EOR). EOR is a practice that allows fossil fuel companies to inject CO₂ into unproductive wells, to retrieve oil and gas that would otherwise be unavailable via traditional methods. The USE IT Act is also meant to drive, though in a somewhat different fashion, the development of carbon capture, utilization, and sequestration (CCUS) activities. The Act, if it becomes law, would provide money for U.S. government research into CCUS and would also support public-private investigation into and development of new CCUS technologies and pipelines to transport captured carbon.

In both instances, these efforts have received bipartisan support, which is a rarity in relation to any feature of contemporary U.S. politics and particularly rare in relation to energy and climate policy. In addition, both efforts have received broad support from a coalition of environmental NGOs and fossil fuel industry groups that work as the Carbon Capture Coalition.

The carbon storage step is essential to any implementation of direct air capture or BECCS technologies, in addition to the potential use of carbon capture methods at sources of fossil fuel combustion (e.g. coal-fired power plants). Those environmental groups that have publicly supported 45Q and the USE IT Act have mostly done so on the grounds that the world will need carbon removal technological systems and that anything that can help to develop those systems should be supported. Yet the fact that such systems are even being considered is because of a failure of humanity to this point to effectively wrestle with the existential challenge posed by climate change and because of the stubbornness and intransigence of existing power structures. Tax credits directed to enhanced oil recovery on the back of modeling efforts that nudge towards the status quo seem the very essence of, well, a status quo response. The very companies that have profited via fossil fuel extraction are now being handed additional money to pull additional hydrocarbons out of the ground, in pursuit of (or perhaps for some under the guise of) working on a key element of the response to climate change.

Guarding against carbon removal extractivism will take concerted work. We need, for one thing, work within the IAMs to better characterize a full range of carbon removal options, and, importantly, there need to be supplementary ways of rigorously exploring alternative futures that go beyond the IAMs. We also need to foster a view of carbon removal that goes beyond the highest level finding that carbon removal is an essential or useful component of climate response. As soon as the idea that carbon removal is essential becomes the norm, then established actors and power structures set about nudging carbon removal in preservation of the existing order. Carbon removal can be a part of many *different* climate responses. Some useful thinking on how to move from what I have been calling here an extractivist carbon removal to a carbon removal attentive to all the myriad needs of just climate policy has been captured in recent work by David Morrow and colleagues (see Box 10.2 below).

BOX 10.2 ONE EARTH PRINCIPLES FOR CONSIDERATION OF CARBON REMOVAL

A recent statement published in the journal *One Earth* does an effective job characterizing a set of high-level principles for an anti-extractivist carbon removal (Morrow *et al.*, 2020). The statement was developed by a diverse group of academics, environmental policy practitioners, and civil society representatives. The four principles they arrived at via a consensus-building process are as follows:²

Principle 1: Don't forget the long game. Carbon removal should be thought of as one small piece of an overall response to climate change. The biggest piece of the climate response puzzle will and must continue to be emissions abatement. Carbon removal could be part of a climate response strategy in a variety of ways, from generalized carbon drawdown to compensating for harder-to-abate sectors. Even though there will be important disagreements over what kinds of carbon removal are used in pursuit of what ends, those disagreements do not take away from the need to get started now on carbon removal research, development, and deployment.

Principle 2: It's not all about the carbon. With the above said, it is too easy to get fixated on the carbon drawdown potential of big abstract response options. We cannot lose sight of the social, economic, and environmental implications of carbon removal, and those implications are best seen at the level of individual projects. In addition, notions of equity, desired futures, and transparency must be basic to consideration of carbon removal at all levels.

Principle 3: Split, don't lump. Another way in which a focus on broad categories of carbon removal fails us is by obscuring important differences between different approaches to carbon removal and *within* particular approaches. There are lots of different ways to do direct air capture or afforestation, for instance. Fine-grained analysis of particular options utilized in particular ways in particular locations is the best way to separate the carbon removal good from the carbon removal bad.

Principle 4: Don't bet it all on being right. Carbon removal options might not pan out. Nor, though, should the world count solely on rapid emissions abatement. It is important to begin work on carbon removal options now, not as a way to delay or offset needed work to keep greenhouse gases from entering the atmosphere, but because delaying work now on carbon removal could rob future generations of a needed tool.

Conclusion

Interest in carbon removal is growing. Increasingly, carbon removal options are being considered by scientists and engineers, policymakers, and populations, in response to ever-more dire projections of Earth's future under conditions of anthropogenic climate change. Still, it is impossible yet to say whether carbon removal options will ever be developed at scale or the role that they might play in climate-related actions of the future. Even with such deep uncertainty, though, carbon removal is shaping the climate conversation of today. It is important that the consideration of carbon removal be pushed beyond technical consideration of "how much carbon at what cost" and beyond the boundaries erected by too-narrow readings of climate modeling results towards much deeper examination of the social, environmental, political, and other implications of making carbon removal part of the climate response portfolio, and to avoid having carbon removal

be captured irrecoverably by an extractivist logic. Carbon removal that is done well promises to be an important and useful part of humanity's climate change response. Carbon removal done poorly could simply entrench the very social dynamics and power structures that got the world into this mess in the first place.

Notes

- 1 Article 4(1) of the Paris Agreement reads: "In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty [emphasis added]."
- 2 The headings come directly from the original article. I have then trimmed down the explanatory language. Nuance is necessarily lost in such an exercise. I urge the reading of the original statement of principles for a full account.

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