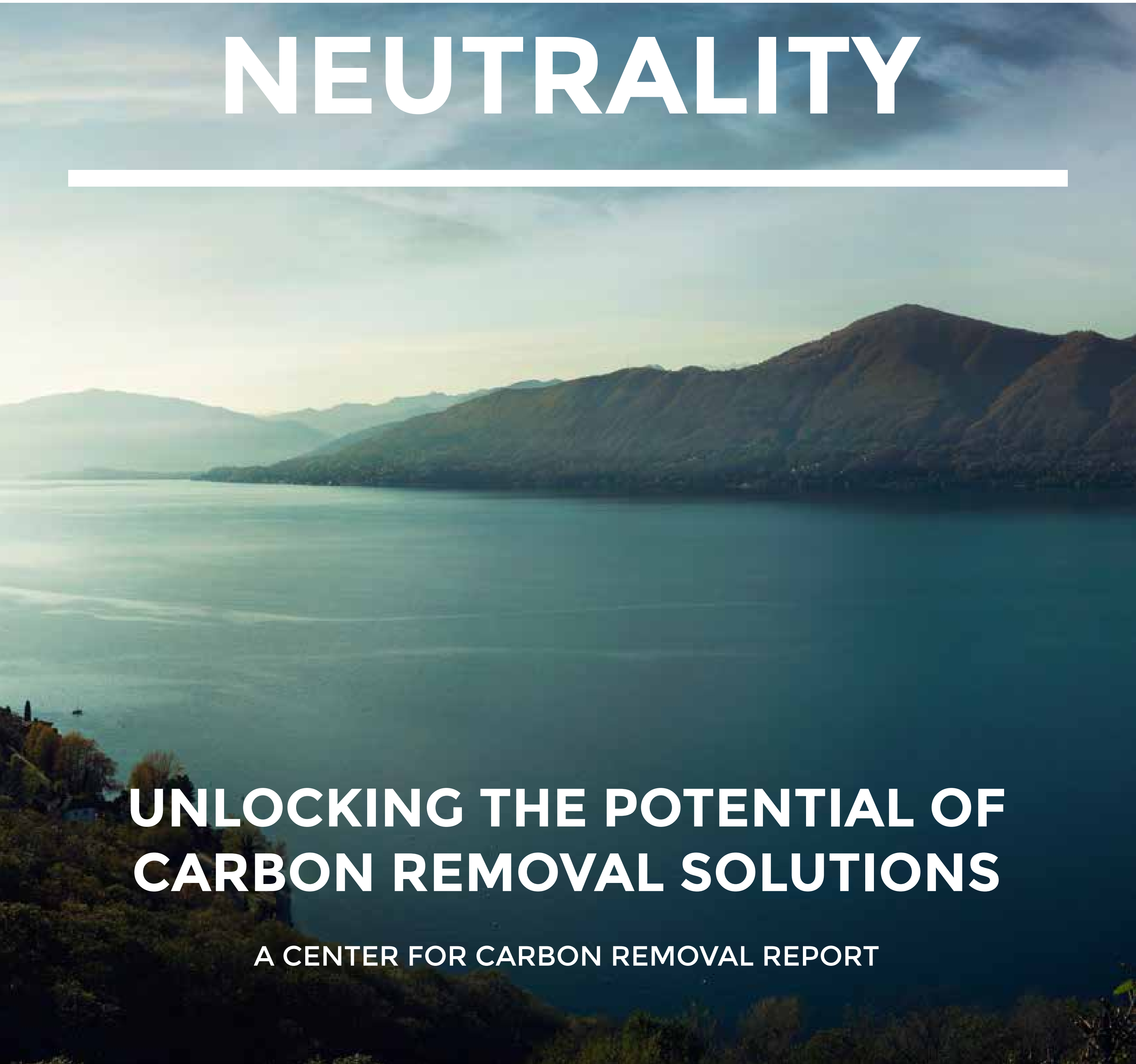
DRAFT FOR PUBLIC COMMENT

PHILANTHROPY BEYOND CARBON NEUTRALITY



UNLOCKING THE POTENTIAL OF CARBON REMOVAL SOLUTIONS

A CENTER FOR CARBON REMOVAL REPORT

DRAFT REPORT: RELEASED FOR PUBLIC COMMENT

Dear readers,

The draft report that follows is the culmination of months of hard work by the team at the Center for Carbon Removal. We have already shared our preliminary conclusions with our advisory board and incorporated their feedback.

Now we want to hear your thoughts. It is important to us that we reflect the community's input on this critically important topic, and we intend to address all the comments from the public that we receive.

The public comment period for this report opened on January 6, 2015, and will close at 8PM Pacific Time on Jan 31, 2016. To submit a comment, please visit the website: www.centerforcarbonremoval.org/publications. After the comment period, we will subsequently publish a response document and the final draft of the report.

A Center for Carbon Removal Core Value: Transparency & Inclusiveness:

We strive to engage the voices of a broad community of stakeholders in an open and rigorous debate on the most appropriate pathways for developing carbon removal solutions.

Thank you in advance for your comments and support with this effort.

Best,
Noah Deich

Noah Deich

EXECUTIVE DIRECTOR
CENTER FOR CARBON REMOVAL

Noah is a professional in the cleantech industry with many years of experience in management consulting, where he worked on clean energy and corporate sustainability projects. Noah has also conducted carbon removal business analyses for investment firms across the globe. Noah received his M.B.A. from UC Berkeley in 2015, and his B.A. from the University of Virginia in 2008.

ABOUT US

The Center for Carbon Removal is a non-profit initiative of the UC Berkeley Energy and Climate Institute dedicated to curtailing climate change. Our focus and mission is to accelerate the development of scalable, sustainable, and economically viable carbon removal solutions. To accomplish this mission, we lead industry and policy collaborations to unlock the potential of carbon removal solutions by conducting research and analysis, convening events, and curating an online hub for information and discussion about carbon removal.

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ALSO BY CENTER FOR CARBON REMOVAL:

Carbon Removal 101

Carbon Farming Factsheet

Direct Air Capture Fact sheet

Please visit www.centerforcarbonremoval.org/publications to access these documents.

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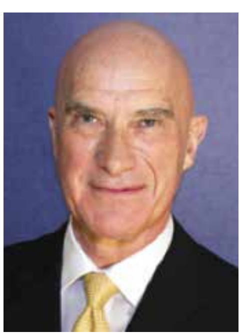
A message from the director of BECI, Dr. Paul Wright, on the motivation behind funding this report:



Carbon removal is a critical yet largely missing piece in the fight against climate change. As the Keeling Curve rises higher and higher above 400ppm each year, it is critical that we develop innovations to bend the path of this curve back down towards pre-industrial levels.

Finding path-bending negative-emissions solutions will demand collaboration from a community of industry, government, academic, and philanthropic organizations—yet we see a paucity of action from all sectors around carbon removal to date.

The key question motivating this report is, "Where do we start?" Given the collective action needed to tackle climate change, as well as the poor state of government action, philanthropy can have a highly catalytic impact today. Funding for this report is motivated by the hypothesis that philanthropies can have a large impact in carbon removal, and that engaging philanthropies in constructive dialogue around carbon removal is urgently needed to advance our understanding and action in this area.

CONTENTS

LIST OF FIGURES

GLOSSARY

B – billions
BECCS – bioenergy with carbon capture and storage
°C – degrees Celsius
CCS – carbon capture and storage
CDR – Carbon dioxide removal
CO_2 – carbon dioxide
EOR – enhanced oil recovery
EU – European Union
ETS – Emissions Trading Scheme
FIT – feed in tariff
GHG – greenhouse gas
IPCC – Intergovernmental Panel on Climate Change
ITC – investment tax credit
M – millions
NAS – National Academies of Science, Engineering, and Medicine
NREL – National Renewable Energy Laboratory
PV – Photovoltaic
R&D – research and development
RD&D – research, development, and demonstration
RGGI – Regional Greenhouse Gas Initiative
t – metric tons
U.S. DOE – United States Department of Energy
U.S. GAO – United States Government Accountability Office
U.S. EPA – United States Environmental Protection Agency

EXECUTIVE SUMMARY

- **Experts say carbon removal is a critical but missing piece of the climate solutions portfolio**
- **Philanthropy can make a huge difference in carbon removal given government/industry inaction**
- **In the past, high costs & tech uncertainties have driven funders away from carbon removal projects**
- **How can philanthropy move beyond carbon neutrality? 1) elevate the issue, 2) spur RD&D/innovation, 3) support policy**

This Agreement…aims to strengthen the global response to the threat of climate change…by a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels…

UN Framework Convention on Climate Change. Paris Agreement. Article 2. Page 22. December 12, 2015.

THE CONTEXT

The Paris Agreement on climate change has united the world in the pursuit of an ambitious climate goal. However, goals alone will not avert catastrophic climate change. Credible commitments to aggressive action are also needed. And on this front, the world leaves much to be desired: the collective national mitigation pledges submitted in advance of COP21 fall far short of what is needed to achieve the goals agreed upon in Paris.

In order to curtail climate change, we must dramatically pick up the pace on climate mitigation action. Rapid mitigation will require that we deploy all the solutions we can to reduce carbon dioxide (CO_2) emissions. But we cannot stop there. It will also be important to develop solutions to remove excess CO_2 that has accumulated in the atmosphere over the past century of industrial activity.

Here is where the missing piece of the climate solutions puzzle, carbon removal (i.e. "negative emissions"), enters the picture. Carbon removal solutions—including landscape restoration, carbon-sequestering agriculture, and negative-emissions energy technologies—can work alongside traditional emissions abatement strategies (such as renewable energy and ecosystem conservation) to strengthen climate mitigation action.

What makes carbon removal solutions particularly valuable is their unique ability to take excess CO_2 out of the atmosphere. Without carbon removal, it will take millennia for natural processes to return atmospheric CO_2 concentrations close to pre-industrial levels—even if we completely eliminate CO_2 emissions.

Pictured: Carbon removal has the ability to create carbon-negative energy systems

For this reason, scientists expect carbon removal solutions to play a large role in the fight against climate change, as outlined in the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report. In this report, 87 percent of modeling scenarios consistent with 2°C of warming involve large-scale deployments of carbon removal that, when coupled with aggressive emissions reductions, result in net-negative global emissions by the end of the 21st century.

The scale and speed with which experts expect carbon removal solutions can be deployed is dramatic. Some IPCC scenarios show new capacity additions of negative-emission power plants on the order of 25 gigawatts (GW) (equivalent to about 50 average-sized coal power plants) annually as early as 2040, despite the fact that no such negative-emissions power plants are operational today. As a point of reference, the "solar miracle" took over 30 years from the installation of the first solar photovoltaic (PV) project before 25 GW of projects were installed in a given year.

87% of IPCC modeling scenarios consistent with 2°C of warming involve large scale deployments of carbon removal

Despite their clear value, carbon removal solutions remain significantly underdeveloped today. Uncertainties around the costs, reliability, sustainability, and/or social acceptability of carbon removal solutions have stymied the investments and dampened the support needed to bring these emerging technologies to market. Delaying action to address these challenges any longer will significantly jeopardize our ability to put the brakes on runaway climate change.

THE OPPORTUNITY

Despite the chorus of scientists calling for urgent action to develop carbon removal solutions, governments and corporations alike have yet to start investing significant amounts into research, development, and demonstration (RD&D) for carbon removal solutions. In addition, existing markets and policies do not create a strong demand for carbon-removing products and services.

The present inaction around carbon removal creates an enormous opportunity for philanthropies to kick-start the development of the field. In the past, philanthropies have succeeded at catalyzing public- and private-sector support for important, off-the-radar social and environmental issues—exactly what the carbon removal field needs today.

This report aims to help:

1) Philanthropic organizations to understand a) the role that carbon removal can play in their climate change grant-making portfolio, and b) what types of grants can generate the highest impact in the carbon removal field.

2) NGOs, startups, and academic groups related to carbon removal to understand a) how philanthropies are thinking about carbon removal today, and b) where philanthropic funding opportunities are likely to lie in the near future.

3) Corporations and government agencies to identify opportunities for philanthropic partnerships around carbon removal.

Pictured: Increasing forest stocks through reforestation can sequester and store large amounts of carbon

Pictured: Carbon Engineering Direct Air Capture plant. Source: Carbon Engineering

> *"It is clear that removing CO_2 from the atmosphere is and can be valuable, especially given the current likelihood that total carbon emissions will exceed the threshold experts believe will produce irreversible environmental effects."*
>
> National Academy of Sciences. Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration.

Philanthropies do not need to deliver the high financial returns required by early-stage technology investors, and they do not face the electoral pressures confronting politicians. Instead, philanthropies can allocate capital for long-term, socially motivated goals that seek to address issues that have yet to gain mainstream interest.

This report explores the role that philanthropies can play in accelerating the development of carbon removal solutions. To understand what actions philanthropies are currently taking around carbon removal, we analyzed a Foundation Center database of philanthropic grant making in the U.S. from 2008 to 2014 and conducted a series of 50 interviews with philanthropic stakeholders and carbon removal experts to provide deeper insights into philanthropic motivations around carbon removal.

We found that philanthropies provided only minimal funding specifically to carbon removal projects—averaging $0.8 million per year—from 2008 to 2014, representing 0.3 percent of total climate-related philanthropy recorded over the timeframe in question.

Interviews suggest that philanthropies have avoided grants related to carbon removal in the past due to the relatively high complexity and cost of these projects, especially compared to other mitigation approaches. Funding for carbon removal projects to date has been motivated in large part by the co-benefits these solutions frequently offer. And funding to carbon removal pathway approaches—particularly fossil energy with carbon capture and storage—has largely ignored the potential for these projects to pave the way for negative-emissions projects in the future.

PHILANTHROPY BEYOND CARBON NEUTRALITY

Philanthropies can lead the charge to develop carbon removal solutions in a number of ways, including by funding initiatives that:

- Elevate the conversation on carbon removal among industry and policy leaders
- Build the case and advocate for RD&D and technology innovation across a broad portfolio of carbon removal solutions
- Identify and advocate for appropriate policy mechanisms to support the development of carbon removal

Pictured: Certain agricultural techniques like agroforestry and no till agriculture can help soils store carbon

To maximize the probability of success, philanthropies can co-create grant-making strategies with industry, government, and civil society to build effective coalitions for advancing carbon removal solutions.

It will also be important to measure the impact of grants with metrics beyond simple cost-effectiveness, in order to capture the value of carbon removal as a complement—not a substitute—to other climate solutions.

Developing a portfolio of sustainable, scalable carbon removal systems to deploy alongside emission abatement and climate adaption solutions will be both a monumentally challenging and invaluable undertaking. Public-, private-, and civil-sector actors will all have to collaborate to ensure carbon removal solutions develop as swiftly and appropriately as needed, and philanthropy can play a key role in convening these key stakeholders and igniting the action needed to build a global economy that cleans up more CO_2 from the atmosphere than it emits.

REPORT STRUCTURE:

1) Background: A deep dive into the science behind carbon removal, explaining why carbon removal is so valuable and what challenges need to be addressed to unlock this potential.

2) Analysis: An exploration of the strategic fit for philanthropy in developing carbon removal solutions, as well as our analytic methods for understanding the role that philanthropies are playing in carbon removal today.

3) Results: A discussion of the findings of our data analysis and interviews with philanthropies and carbon removal experts.

4) Beyond Carbon Neutrality: A starting point for philanthropies to catalyze the development of carbon removal strategies.

BACKGROUND

SECTION 1

SECTION SUMMARY:

- *Carbon removal is a critical but missing part of climate solutions portfolio*
- *The opportunities around carbon removal are large, but so are the challenges; commercialization will take time*
- *Industry and policy support for carbon removal is limited, though urgently needed*

Experts increasingly agree that carbon removal is a critical, yet missing, piece of the climate change solutions portfolio. Urgent action is needed to develop carbon removal solutions today, as carbon removal solutions will likely take decades to reach commercial maturity. Many sectors of the economy hold potential for removing meaningful amounts of CO_2 from the atmosphere, including forestry, agriculture, energy, manufacturing, and mining. However, all of the carbon removal approaches identified today face major barriers around cost, scale potential, sustainability, and/or reliability of sequestration. Government and industry support for the field remains limited—without increases in funding and policy today, carbon removal solutions will struggle to develop swiftly.

1.1 THE CASE FOR CARBON REMOVAL

Over the coming decades, a wide range of solutions must be deployed to stabilize atmospheric concentrations of greenhouse gases (GHGs) and to help communities adapt to changes in climate already underway (See Figure 1). While clean energy and adaptation efforts have ramped up in recent years, "carbon removal" solutions capable of removing and sequestering excess carbon dioxide from the atmosphere have failed to gain the industry and government support needed to flourish and will likely require decades of development to reach commercial maturity.

DEFINITION: CARBON REMOVAL

Any process, technology, or system capable of removing and reliably sequestering carbon from the air over its life cycle.

"removing CO_2 from the atmosphere is and can be valuable" — the National Academies of Sciences Climate Interventions (2015)[1] *@TheNASEM*

Figure 1. Carbon Removal: A Missing Piece of the Climate Solutions Portfolio

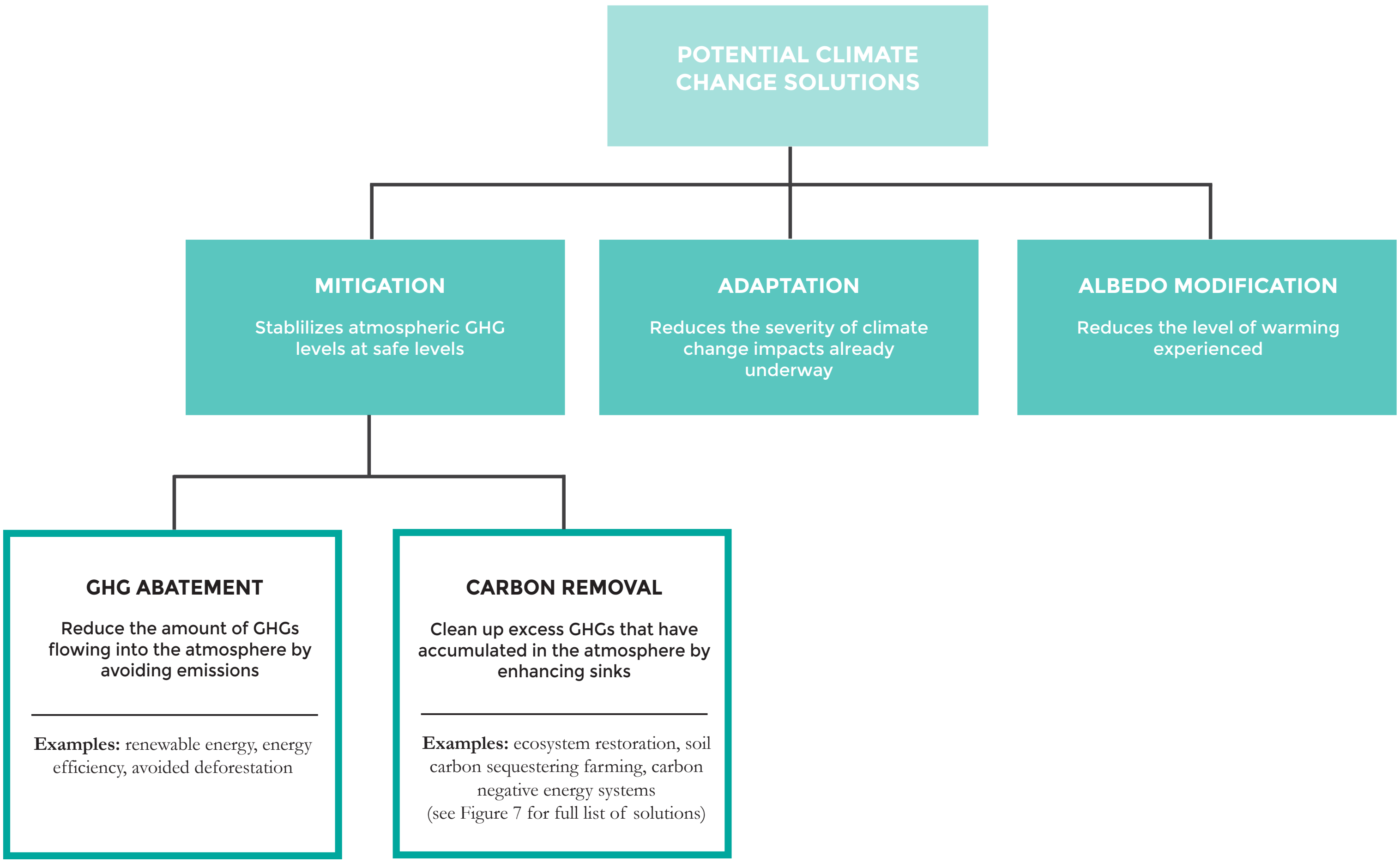


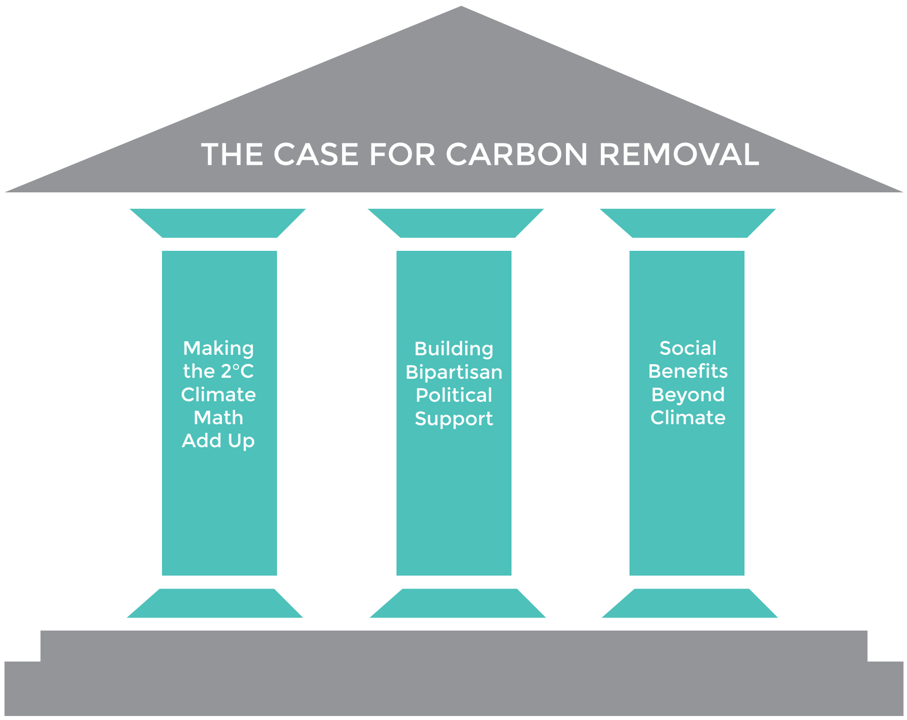
Figure 2. IPCC Sends Mixed Messages About Carbon Removal Taxonomy

> "Mitigation is a human intervention to reduce the sources or **enhance the sinks** of greenhouse gases."

> "Geoengineering by **CDR [Carbon Dioxide Removal]** or solar radiation management (SRM)" [2]

The IPCC provides no guidance about the difference between "enhancing carbon sinks" and "carbon dioxide removal." To resolve this issue, this report only considers those carbon removal solutions that fit the popular definition of "mitigation." For solutions excluded from this report, please see page 24 for more information.

Figure 3. The Case for Carbon Removal



OTHER NAMES FOR CARBON REMOVAL

- Carbon Dioxide Removal (CDR)
- Greenhouse Gas Removal (GGR)
- Negative Emission Technologies (NETs)
- Enhanced Carbon Sinks
- Carbon Sequestration—though carbon sequestration can also refer to low- and no-emission climate solutions (and thus are not necessarily carbon removal).

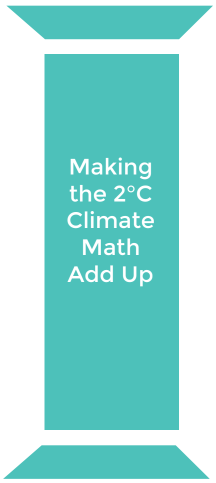
This section explores three main reasons why the development of carbon removal solutions is imperative (as shown in Figure 3):

Pillar 1: Making the 2°C climate math add up
Carbon removal is increasingly critical for preventing temperatures from rising above the internationally agreed safe limit of 2°C compared to pre-industrial times.

Pillar 2: Building bipartisan political support
Carbon removal can help build larger bipartisan political coalitions in support of aggressive, overarching climate policy.

Pillar 3: Social benefits beyond climate
Many carbon removal approaches hold benefits beyond climate mitigation that are valuable to society today.

PILLAR 1: MAKING THE 2°C CLIMATE MATH ADD UP



To curtail climate change, a rapid economic transition away from fossil fuel consumption and emission-generating land-management practices is necessary. While it is technologically possible to stop emissions quickly enough to prevent temperatures from rising above the 2°C limit considered by the international community as "safe,"[3] marshaling the political support required to curtail climate change through GHG emission abatement alone looks increasingly difficult. This subsection explains why the climate math for staying below the 2°C warming limit looks so challenging without carbon removal and why deploying carbon removal solutions in addition to GHG abatement strategies will likely prove critical for stabilizing atmospheric GHG concentrations at safe levels.

THE 2°C CLIMATE MATH AND CARBON BUDGETS

The idea of a "carbon budget" is central to the math of curtailing climate change. A carbon budget is a fixed quantity of GHG emissions that, if exceeded, corresponds to a given temperature increase. The carbon budget remaining for limiting temperature increases to 2°C relative to pre-industrial times is roughly equivalent to 1,000 billion tons of CO_2-equivalent (CO_2-eq).[4] At the present rate of annual GHG emissions (around 50 billion tons of CO_2-eq per year and growing), the carbon budget corresponding to 2°C of climate change will be exhausted in less than two decades.*

Further, there is significant uncertainty as to whether this 1,000-ton CO_2-eq carbon budget will actually limit global temperature increases to 2°C. Scientists estimate that this 1,000 billion ton CO_2-eq budget corresponds to a 66% probability that temperature increases will stay below 2°C by the end of the century (as shown in Figure 4). To have a higher confidence that temperatures will stay below 2°C, an even smaller carbon budget must be maintained, which the IPCC notes "only a limited number of individual model studies have explored."[7]

The climate math is clear: rapid GHG emissions reductions are needed to curtail climate change

***195 countries have now committed to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" as stated in Article 2 of the Paris Agreement.[5] Many in the scientific community see 2°C as too high a limit to protect the most vulnerable populations against climate change, but carbon budgets associated with 1.5°C of warming will be exhausted in less than a decade without significant emissions reductions.[6]**

Figure 4. The Carbon Budget Math[8]

Carbon budget (billion t CO_2-eq)	Atmospheric GHG concentration (parts per million in 2100)	IPCC Scenario Name	Likelihood of staying below total warming by 2100			
			1.5°C	2.0°C	3.0°C	4.0°C
630-1180	430-480	RCP 2.6	> 50%	> 66%	> 66%	> 66%
1870-2400	580-650	RCP 4.5	< 33%	< 50%	> 66%	> 66%
2570-3340	650-720		< 33%	< 33%	> 50%	> 66%
3620-4990	720-1000	RCP 6.0	<< 33%	< 33%	< 50%	> 66%
5350-7010	>1000	RCP 8.5	<< 33%	< 33%	< 33%	< 50%

The window for preventing 2°C of warming is rapidly dwindling. In order to try to limit warming to below 2°C with greater than a 66% probability, the remaining carbon budget is roughly 1,000 billion tons of CO_2-eq.

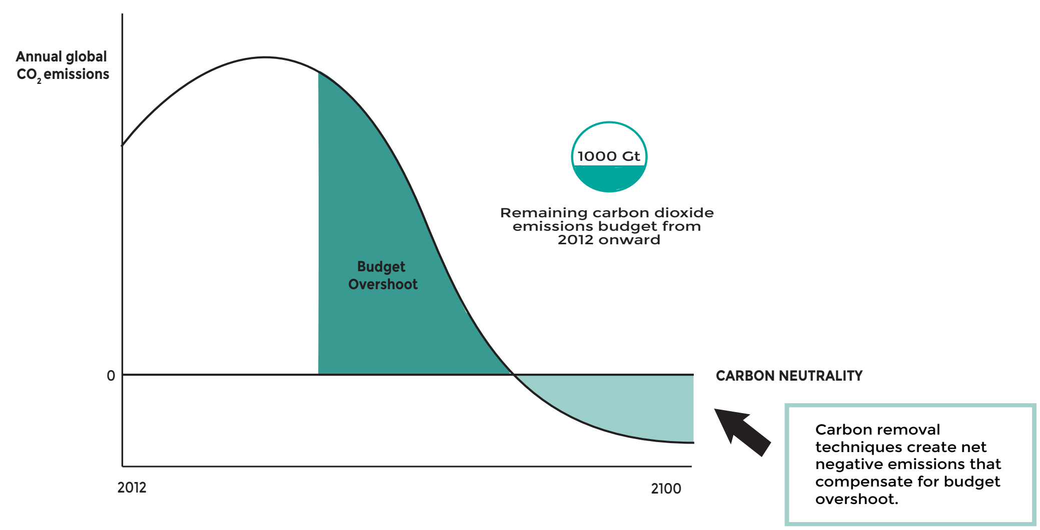
INCREASINGLY LIKELIHOOD OF CARBON BUDGET OVERSHOOT

Current GHG emissions reductions targets set by the international community create considerable risk that GHG emissions will decrease too slowly to stay within the carbon budget associated with 2°C of warming.

A report by UN Framework Convention on Climate Change (UNFCCC) Secretariat noted that, "considering the aggregate effect of the INDCs [Intended Nationally Determined Contributions—i.e. national climate action plans], global cumulative CO_2 emissions are expected to equal 54 (52–56) per cent by 2025 and 75 (72–77) per cent by 2030 of that 1,000 Gt CO_2" carbon budget.[9] In other words, planned climate action alone will exhaust the vast majority of the carbon budget associated with 2°C of warming over the next 15 years.

Even w/ international climate commitments, we are on pace to exhaust emissions budgets in a few decades

Figure 5. Carbon Removal Vital in Case of Emissions Budget Overshoot



If our remaining carbon budget is exhausted before GHG emissions neutrality is reached, only negative emissions can compensate for this overshoot of emissions to keep levels of warming below dangerous levels. Graphic adapted from the UNEP 2014 Emissions Gap Report.[11]

Restoring degraded wetland ecosystems like mangroves and peatlands can sequester carbon from the atmosphere

CARBON REMOVAL IS A SAFEGUARD FOR BUDGET OVERSHOOT

It is entirely possible that the world will take greater collective action to curtail GHG emissions than current commitments suggest. But there are a number of scenarios that would make it necessary to deploy carbon removal solutions alongside GHG abatement solutions to prevent dangerous climate change (Figure 5), including:

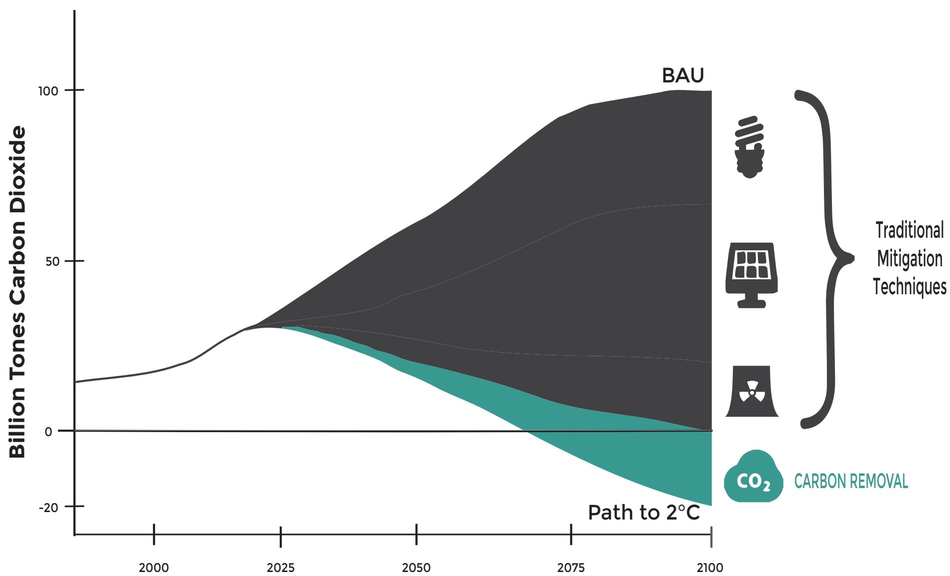
• Existing GHG abatement commitments are not increased as aggressively as is needed

• The emissions budget associated with 2°C of warming turns out to be smaller than the 1,000 billion tons CO2-eq that is currently estimated

•2°C of warming is determined to be unacceptably high

"Sticky" CO_2: emissions remain in the atmosphere for centuries, making CO_2 removal necessary if decarbonization moves slowly

Figure 6. Pathways to 2°C Require GHG Abatement & Carbon Removal



A broad portfolio of carbon removal solutions is required to limit the impacts of climate change: GHG abatement techniques and carbon removal solutions. Adapted from Climate Institute Report Below Zero: Carbon Removal and the Climate Challenge.[12]

The reason that carbon removal is needed in these scenarios is that scientists estimate that it "will take a few hundred thousand years" for the complete removal of human-emitted CO_2 from the atmosphere by natural processes alone.[10] That is to say, if we reach dangerous atmospheric GHG concentrations, it will take millennia to restore the atmosphere to safe levels if carbon removal solutions are not also deployed.

Carbon removal is a critical complement to — not a substitute for — deep GHG emissions reductions

This leads to a subtle but important point: only carbon removal solutions are capable of generating negative GHG emissions globally. Renewable energy, energy efficiency, and ecosystem conservation strategies can only reduce GHG emissions. This fact makes carbon removal a complement to, not a substitute for GHG abatement solutions—we need both to decarbonize the economy (i.e. stop emitting GHGs) and to clean up the excess CO_2 that has accumulated in the atmosphere (as shown in Figure 6).

CARBON REMOVAL IS WIDESPREAD IN CLIMATE MODELS

Large-scale carbon removal is already prevalent in academic climate models

87% of the IPCC's scenarios consistent w/ 2°C of warming involve net-negative emissions globally by 2100

IPCC scenarios consistent w/ 2°C include up to 25GW of negative emission energy annually starting in 2040

Climate models increasingly use carbon removal solutions alongside other mitigation techniques to meet climate goals. For example, the IPCC's climate modeling scenarios "typically rely on the availability and widespread deployment of [bioenergy and carbon capture and storage] and afforestation [two types of carbon removal solutions] in the second half of the century" to stabilize temperatures below 2°C.[13]

A paper recently published in Nature Climate Change highlights that, of the IPCC's "116 scenarios consistent with >66% probability of limiting warming below 2°C … 101 (87%) apply global NETs [Negative Emission Technologies] in the second half of this century."[14] Critically, this paper shows that carbon removal is also prevalent in "many scenarios that allow CO_2 concentrations to grow between 480 and 720 ppm CO2-eq. by 2100 [i.e. scenarios that involve greater than 2°C warming] … with 235/653 (36%) delivering net negative emissions globally."[15]

In total, the average 2°C scenario in IPCC modeling includes over 160 billion tons of cumulative carbon removal by 2100—meaning that even in scenarios involving aggressive GHG abatement action, 2°C carbon budgets are exceeded by about 15%.[16]

Climate modelers also assume that carbon removal will play a large role in near-term climate action. Representative 2°C scenarios used in IPCC modeling assume annual deployments of carbon-removing energy systems will grow from zero today to about 25 GW by 2040—an amount equivalent to building 50 average-sized coal plants per year. [17]

Pictured: Certain grazing techniques can sequester and store carbon in soils.

Pictured: All Power Labs, a company working towards carbon negative energy, with their biomass gassifier. Source: All Power Labs

> *The bottom line is that the scientific community is clear: If we do not swiftly develop and deploy carbon removal systems alongside other GHG abatement approaches, the math to limit average temperatures to 2°C will quickly fail to add up.*

PILLAR 2: BUILDING BIPARTISAN POLITICAL SUPPORT FOR BROAD CLIMATE ACTION

Carbon removal solutions hold the potential to increase political support for climate action

Carbon removal solutions offer innovative business opportunities across the globe

Carbon removal solutions also hold the potential to increase political support for swift, overarching climate action. For one, carbon removal solutions can reduce the overall cost of curtailing climate change by expanding the set of climate mitigation options. Inexpensive carbon removal approaches in the forestry and agriculture sector can provide cost-effective offsets for difficult-to-decarbonize sectors (such as aviation and freight) while carbon-free alternatives for these industries develop. If carbon removal solutions can help bring down the overall cost of curtailing climate change, the case that strong action on climate will cripple the economy and restrain economic development will weaken considerably.

In addition, carbon removal solutions offer innovative business opportunities across the globe in many sectors of the economy, including forestry, agriculture, energy, manufacturing, and mining (more details in Section 1.2). These sectors—and the national governments that represent them—have been indifferent or even hostile to climate action in the past, as strict GHG emission regulations threaten their competitiveness. By creating business opportunities around carbon removal solutions, there will be more options for these threatened industries to thrive in a low-carbon world. Seeing the business opportunities that could stem from carbon removal could reduce opposition and/or encourage greater industry support for aggressive, comprehensive climate action.

Social Benefits Beyond Climate

PILLAR 3: SOCIAL BENEFITS BEYOND CLIMATE

Many carbon removal solutions hold significant potential to provide benefits beyond climate mitigation. These additional benefits make efforts to develop carbon removal solutions today a "no regrets" strategy.

Carbon removal solutions can offer many co-benefits beyond climate mitigation

The co-benefits of carbon removal systems can include:

• **Climate adaptation:** In the agriculture and forestry sectors, several carbon removal solutions can also aid in adapting to the effects of climate change. Potential adaptation benefits of carbon removal approaches include enhancing crop resiliency to weather extremes, increasing the ability of soils to hold water and other nutrients, protecting against increased storm surges due to sea level rise, and decreasing the number and severity of wildfires.

• **Non-climate environmental benefits:** Other carbon removal approaches can help improve natural ecosystems and enhance biodiversity, which in turn generate valuable ecosystem services for communities across the globe.

• **Social justice and economic development:** Some carbon removal solutions can empower communities with tools to fuel sustainable economic growth. For example, biochar cookstoves can improve indoor air quality as compared to conventional biomass cookstoves, and carbon-farming techniques can increase agricultural yields and in turn create profits and ensure food security for rural communities.

Pictured: SeaChar Estufa Finca cookstove in Nicaragua. The stove helps reduce indoor air pollution and produces biochar that can be used as a soil amendment.

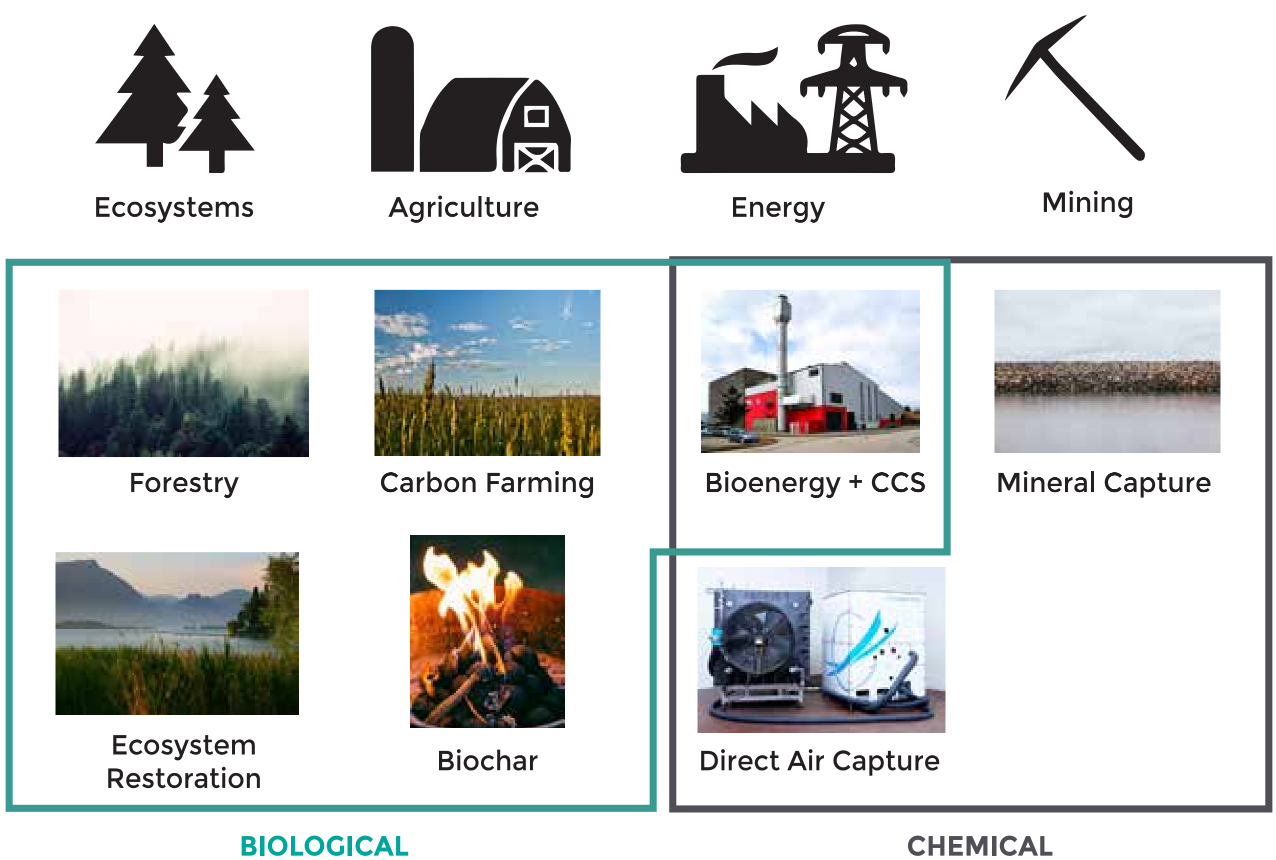
Source: SeaChar

1.2 OPPORTUNITIES & CHALLENGES

POTENTIAL SOLUTIONS

A broad range of solutions have the potential to provide scalable, sustainable, and reliable carbon removal, but each faces significant challenges. This subsection explores the opportunities and challenges for carbon removal and shows why it is likely too early to pick winners and losers from proposed carbon removal approaches. Instead, a research and development effort that targets a broad portfolio of carbon removal solutions is urgently needed.

Figure 7. Summary of Carbon Removal Approaches By Sector



A number of carbon removal solutions have begun to emerge as critical complements to other GHG emissions mitigation options. While the list of proposed carbon removal approaches is extensive, approaches can roughly be categorized according to two carbon-capture pathways: biological and chemical (or a hybrid of the two), shown in Figure 7.

Numerous carbon removal solutions have potential, but each faces challenges

BIOLOGICAL CARBON REMOVAL

Biological carbon removal systems harness the ability of photosynthesis to capture carbon from the air. Because photosynthesis naturally results in a carbon-neutral cycle (plants release carbon back into the atmosphere when they die and decompose), biological carbon removal systems can generate net-negative GHG emissions in one of two ways: 1) by increasing the relative balance of carbon in terrestrial ecosystems compared to the atmosphere, and/or 2) by employing processes that prevent the release of photosynthetically captured carbon back into the atmosphere.

Example solutions include:

1. Carbon farming: Certain agricultural techniques have been shown to increase plant stocks in a given area of land and/or to enhance the ability of soils to uptake and store carbon. Some of the practices that help enhance natural carbon storage include conservation tillage, cover cropping, crop rotation, compost application, and rotational livestock grazing. These techniques hold the potential to increase soil organic matter through decomposition above ground (in crop residues, animal wastes, etc.) or growth below ground (soil biota, roots, etc.).

2. Ecosystem restoration: Many ecosystems provide natural carbon sinks, but have been degraded over time by agricultural and urban expansion. Restoring carbon-storing ecosystems like peatlands and mangroves sequesters carbon in plant material and soils, while also providing numerous other ecosystem services.

3. Reforestation and Afforestation: Reforestation and afforestation (planting of forests in areas previously not forested) can remove CO_2 from the atmosphere and store it in plant material. Avoided deforestation is not considered a carbon removal technique because it only maintains, rather than enhances, natural sinks.

4. Biochar: Biochar (referred to in other contexts as charcoal) results from the pyrolysis of biomass, which involves heating biomass in the absence of oxygen. Biochar systems rely on plants to pull carbon out of the air through photosynthesis. The pyrolysis process then transforms that biomass into a stable biochar that decomposes slowly (and thus does not release carbon back into the air for decades, if not centuries). The resulting biochar product can be used for agriculture (as a soil amendment), waste treatment (as a filter), and/or land reclamation.

HYBRID BIOLOGICAL/CHEMICAL CARBON REMOVAL

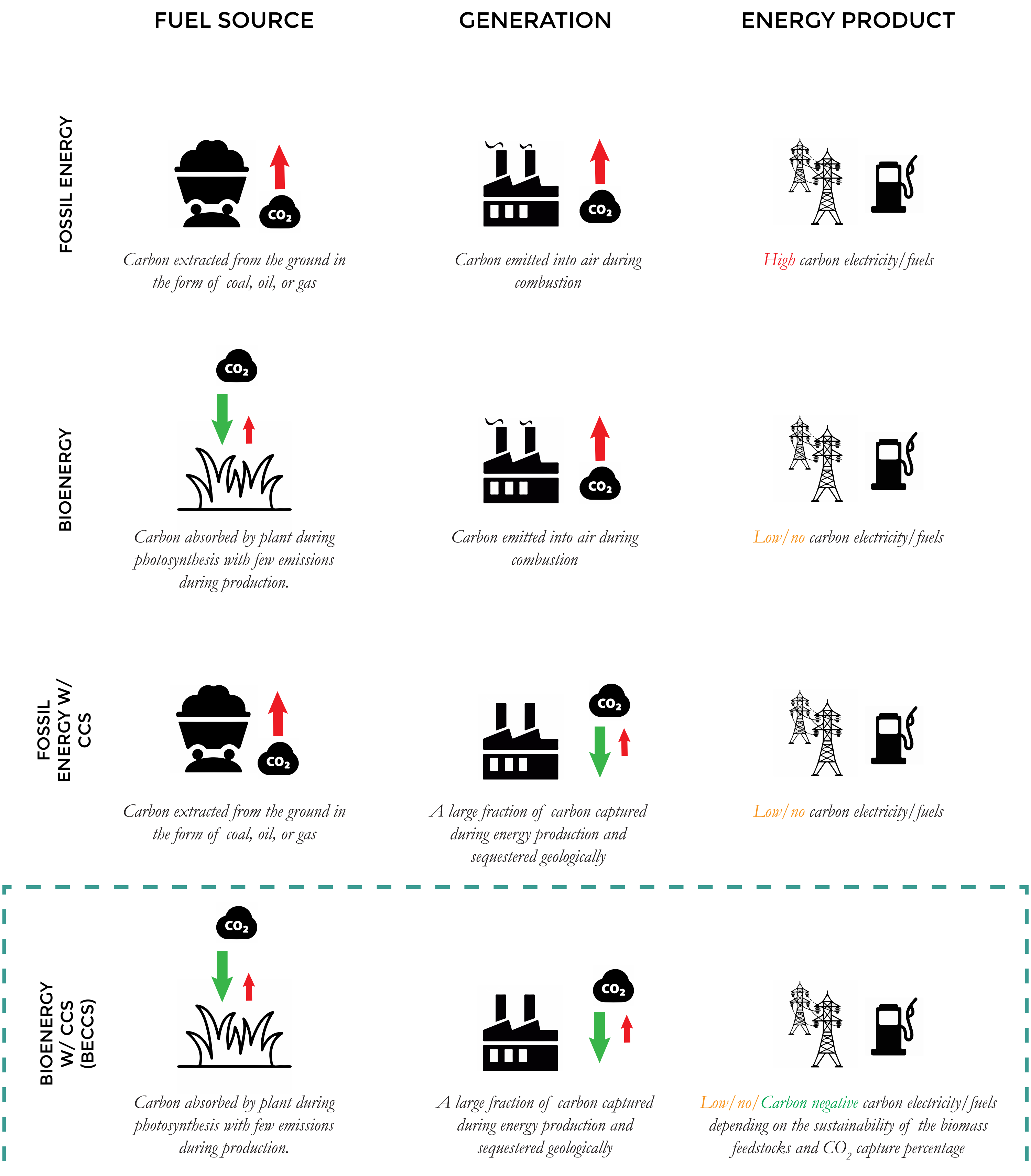
5. Bioenergy with Carbon Capture and Storage (BECCS or BioCCS): Traditional biomass power generation and/or fuels production has the potential to be a net-negative GHG emission technology when coupled with carbon capture and storage (CCS). In traditional carbon-neutral bioenergy production, biomass feedstocks absorb carbon from the air, which is subsequently released back into the atmosphere during the energy production process. If CCS systems—which capture CO_2 from the power plant and sequester CO_2 in underground geologic formations or in non-degradable carbon materials (such as cements, plastics, etc.)—are deployed in conjunction with bioenergy production, the carbon in the biomass feedstocks is prevented from escaping back into the atmosphere during energy production, creating net carbon removal from the atmosphere.

CCS systems coupled with bioenergy production for carbon removal are very similar to CCS systems coupled with fossil energy production for GHG abatement purposes. Because it is possible to combine biomass and fossil fuels at the same facility through biomass co-firing, deploying fossil energy production with CCS holds the potential to help pave the way for deployment of BECCS in the future. Fossil energy with CCS can also demonstrate the geologic sequestration techniques that can be deployed with BECCS. Yet by itself, fossil energy with CCS is not a carbon removal solution (for co-fired systems, the percentage of biomass co-fired determines whether the system removes carbon on net).

Pictured: Bioenergy plant in Germany.

Source: Johann Jaritz via Wikimedia

Figure 8. Bioenergy + CCS Explained



CHEMICAL CARBON REMOVAL

Chemical carbon removal approaches strip carbon from the air by artificial processes analogous to natural photosynthesis, or they work by speeding up chemical reactions that occur naturally between certain minerals and CO2 in the air.

6. Direct Air Capture: Direct air capture (DAC) and storage – This category includes technologies that can capture industrial-scale quantities of CO_2 from ambient air using solvents, filters, or other methods. Because direct air capture systems do not generate energy, they create net-negative emissions only when powered with low-carbon energy sources (i.e. when the CO_2 sequestered is greater than the CO_2 emitted to power the system). Although DAC systems can also be deployed to mitigate GHG emissions by making carbon-neutral fuels and chemicals, these applications of DAC are not considered carbon removal.

Pictured: ClimeWorks modular direct air capture technology. Source: ClimeWorks

The technology deployed in DAC systems can overlap with the technologies used for traditional CCS from exhaust gas. The main difference between DAC and CCS from power plant exhaust gas is that power plant exhaust streams have concentrations of CO_2 between 5 and 15% depending on the fuel source, while the CO_2 concentration of ambient air for DAC is orders or magnitude more dilute (around 0.04%). The relatively dilute concentration of CO_2 in the atmosphere requires DAC systems to employ novel designs and chemicals used for capture. A key benefit of DAC systems is that they can be sited directly over geologic CO_2 storage sites, eliminating the costly CO_2 transportation and permitting considerations associated with traditional CCS systems on power plants.

7. Mineral capture and storage: Leading approaches for mineral capture involve the enhanced weathering of rocks that contain minerals that will bind with CO_2 naturally when exposed to the air. Mineral capture processes accelerate natural CO_2 capture processes that can take hundreds of thousands of years by extracting, crushing, and spreading minerals (such as silicates) over large areas to promote sequestration on a time scale relevant to curtailing anthropogenic climate change.

Pictured: Mineral capture can be facilitated through the mining and pulverization of relatively abundant materials.

POTENTIAL APPROACHES EXCLUDED FROM THIS ANALYSIS

While many carbon removal approaches have been proposed in addition to the previous list of technologies, this report focuses only on solutions where sufficient evidence of their potential efficacy is available. Other more speculative carbon removal approaches—such as ocean iron fertilization and ocean alkalinity enhancement—were excluded from this analysis due to the greater uncertainties and risks for unintended consequences. Novel and disruptive carbon removal solutions have the potential to emerge with greater incentives for innovation in this area.

CARBON REMOVAL "MUST READS"

National Research Council. "Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration." February 2015.

Global Carbon Project. "Betting on Negative Emissions." Sabine Fuss, et al. Nature Climate Change. September 2014.

Global Carbon Project. Peter Smith, et al. "Biophysical and economic limits to negative CO_2 emissions" Nature Climate Change. 2015.

Oxford University. "Stranded Carbon Assets and Negative Emissions Technologies." Guy Lomax, et al. Nature Climate Change. May 2015.

UC Berkeley. "Biomass enables the transition to a carbon-negative power system across western North America." Daniel Sanchez, et al. Nature Climate Change. February 2015.

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CHALLENGES FOR REACHING SCALE

While carbon removal solutions show great promise to help curtail climate change, each solution faces significant obstacles to reaching scale. The IPCC notes, "the availability and scale of … Carbon Dioxide Removal (CDR) technologies and methods are uncertain and CDR technologies and methods are, to varying degrees, associated with challenges and risks."[18]

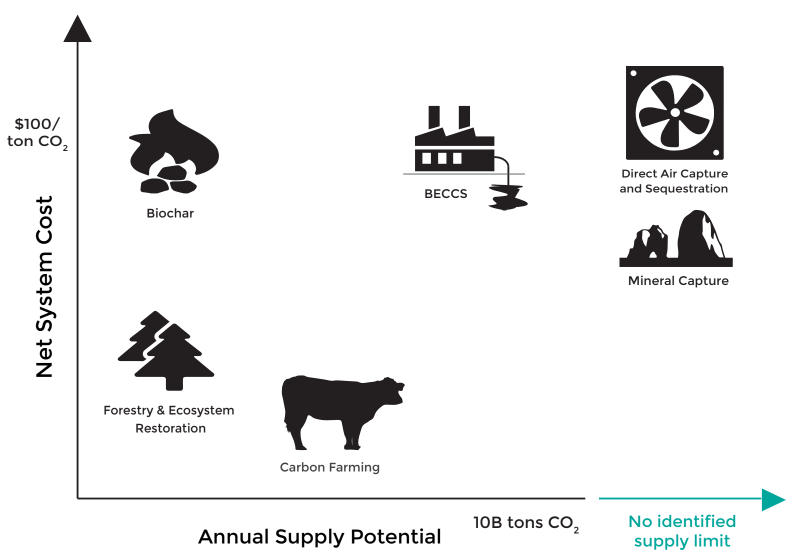
One challenge to reaching scale is technical, as most carbon removal approaches lag behind GHG abatement options in both cost and technology maturity (see Figure 9). Some carbon removal solutions—such as direct air capture and bioenergy with CCS—only have a few pilot and commercial scale plants in operation, making it very difficult to estimate the cost "learning curve" associated with these technologies and thus the eventual cost of these technologies when deployed at scale.[19] Furthermore, many components of CCS technologies more generally have not yet reached technical viability to be deployed at large scales (Figure 10).

Other carbon removal approaches require significant advances in basic science to understand their scale potential. For example, biological sequestration approaches—such as biochar, carbon farming, and reforestation—all face uncertainties in regard to the quantities of lifecycle carbon sequestration, as well as the permanence of carbon sequestration if land-management practices changes or if natural disasters (such as forest fires) occur and release large amounts of stored carbon back into the atmosphere.

DRAFT FOR PUBLIC COMMENT

> ”
>
> *Carbon Dioxide Removal (CDR) … technologies and methods are, to varying degrees, associated with challenges and risks.*
>
> — IPCC 5th Assessment Report on Climate Change

Figure 9. Carbon Removal Scale and Cost Estimates



Cost and supply estimates based on publically available estimates. Major uncertainties still remain as to the ultimate supply and cost potential of all carbon removal approaches.[20]

Beyond cost and technical viability, the social and non-carbon environmental impacts of many carbon removal approaches are not well understood. Land use is a significant concern for many carbon removal approaches. In order to reach the billion-ton-per-year scale (seen as the benchmark for many scientists as climatically significant),[21] many of the biological approaches like carbon farming, forestry, and biomass energy crop production could require that significant amounts of arable land be used for these carbon storage purposes.[22] Using land for carbon storage instead of food-crop production could drive up land and/or food prices significantly, resulting in unintended economic and social stress. Further, implementing these techniques on a large scale can result in indirect land-use change, thus decreasing their climate mitigation benefit.[23]

Additionally, the non-climate social and ecological impacts of many carbon removal approaches are not well understood. There are a host of uncertainties surrounding the impacts of large-scale carbon removal to biodiversity and the environmental more generally from large-scale carbon removal.[24] Further, few dialogues have been held with the key constituencies that may be impacted by carbon removal solutions, and it is imperative that leaders engage in conversations today to understand which carbon removal solutions are most appropriate for the local contexts in which they might be deployed.

Figure 10. Technology Maturity Levels of Various CCS Technologies

Program Area	Key Technology	Number of R&D Projects					Total
		TRL 1	TRL 2	TRL 3-4	TRL 5-6	TRL 7	
Post-Combustion Capture	*Solvents*		3	9	5	-	17
	Sorbents		3	9	2	-	14
	Membranes		4	5	1	-	10
	Hybrid/Novel		5	3	1	1	10
Pre-Combustion Capture	*Solvents*		2	1			3
	Sorbents		2	1	1	-	4
	Membranes		2	5	-	-	7
	Hybrid/Novel		3	-	-	-	3
Compression	*Compression*		-	-	2	-	2
TRL Totals			24	33	12	1	70

Few CCS technologies (carbon negative and carbon neutral) have been deployed, while even fewer have met a "technological readiness level" sufficient for cost-effective commercialization. Taken from the National Energy Technology Laboratory.[25]

CARBON REMOVAL AS A PORTFOLIO

A key takeaway from the scientific literature is that there appears to be no "silver bullet" solution for carbon removal. As a result, developing a broad portfolio of carbon removal solutions will likely generate the highest returns for society and the climate today. Once key uncertainties surrounding potential approaches are addressed, future development efforts can be better informed about which options will emerge as the most valuable for meeting environmental, economic, and social goals in the future.

No "silver bullet" carbon removal solution exists, making the development of a broad portfolio of carbon removal solutions critical

Carbon Removal: The "Venture Capital" of the Climate Portfolio.

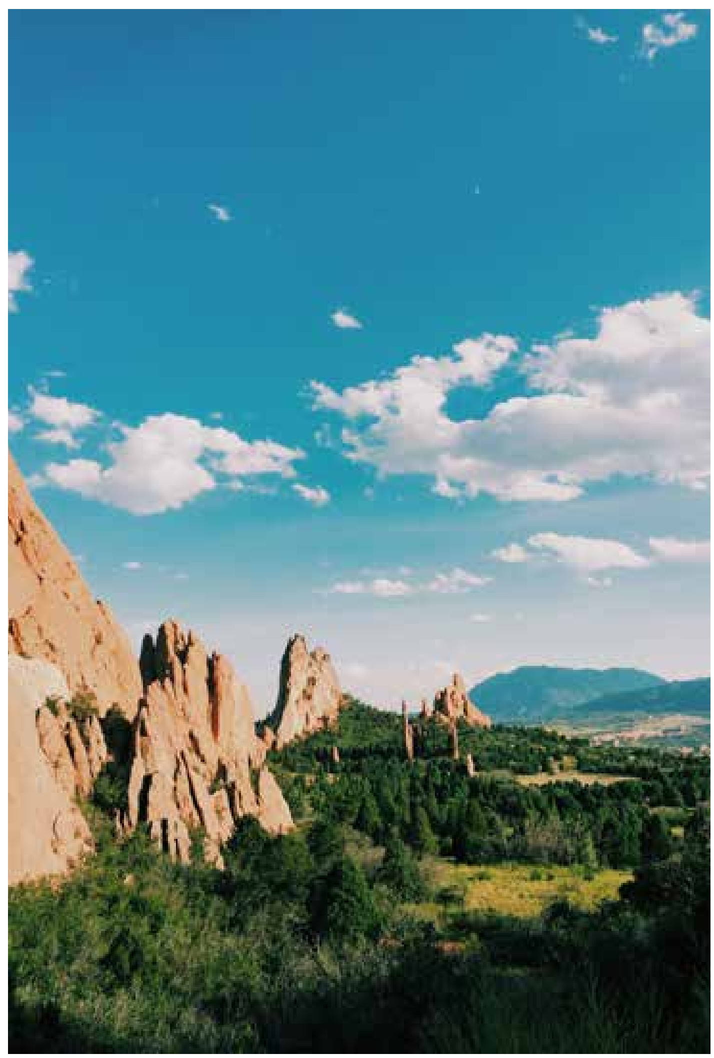
Carbon removal solutions are in many ways analogous to venture capital investments, which only make up a small portion of consistent, risk-averse financial portfolios. In addition, institutional investors usually invest in venture capital funds instead of trying to pick startup investments themselves. In the same way, a diversified portfolio of carbon removal solutions is likely to generate the largest and most consistent climate returns today.

1.3 HELP WANTED

GOVERNMENT & INDUSTRY SUPPORT URGENTLY NEEDED

Large-scale carbon removal will likely take decades to reach commercial maturity

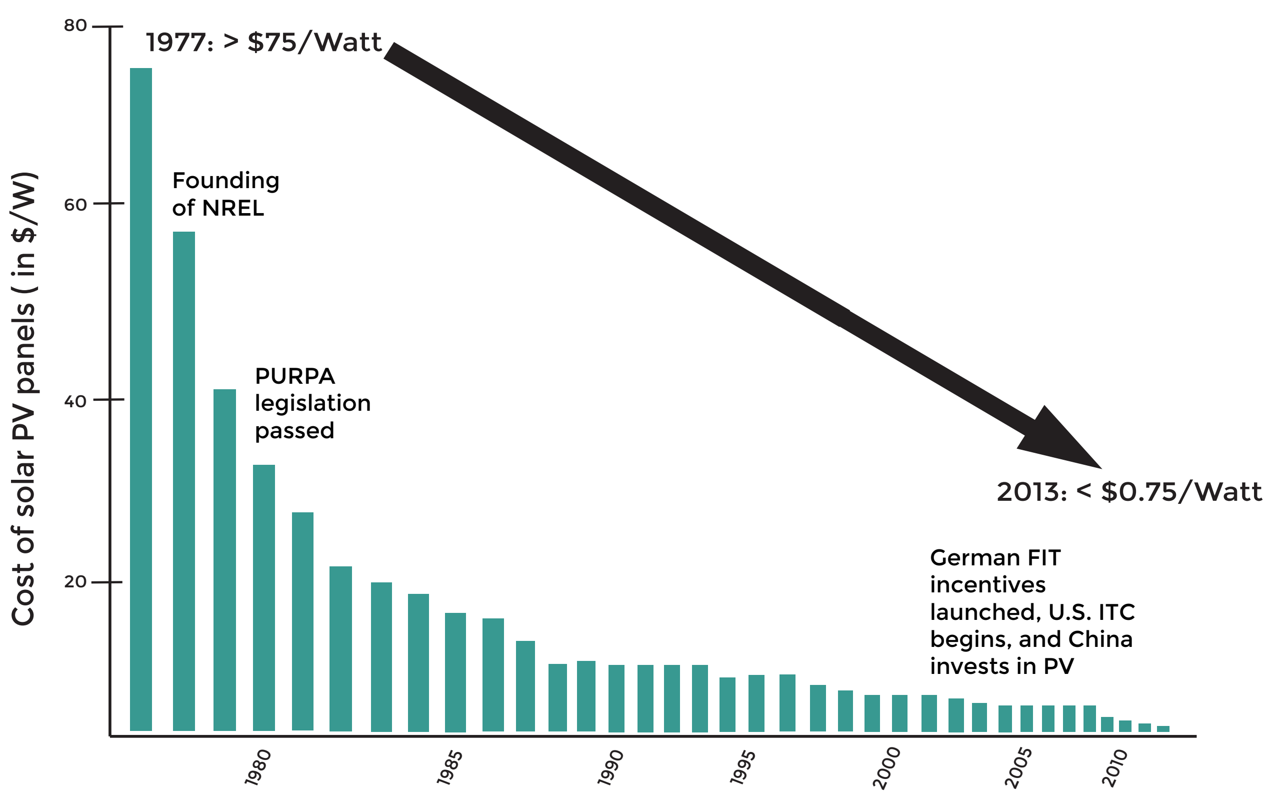
History suggests that addressing the challenges surrounding carbon removal solutions will take decades of concerted government and industry support. For example, it has taken several decades of research, policy advances, and manufacturing experience for renewable energy technologies to reach cost competitiveness with fossil energy alternatives (see Figure 11).[26] Other low-carbon energy systems, such as nuclear energy and fossil energy with carbon capture and storage still require government support, even after decades of commercialization activity. Once developed, carbon removal systems will require large capital expenditures to deploy at the scale projected to be necessary—a recent academic paper published in Nature Energy estimates that it will require trillions of dollars in capital to build out carbon-removing energy systems over the coming decades.[27]



Existing market forces alone are unlikely to stimulate the swift development of carbon removal solutions. The markets that offer opportunities for the utilization of CO_2 (including enhanced oil recovery and the manufacturing of materials such as cements and plastics) are highly competitive, and CO_2 sourced from the atmosphere struggles to compete on cost with CO_2 sourced from fossil fuels or naturally occurring geologic sources.

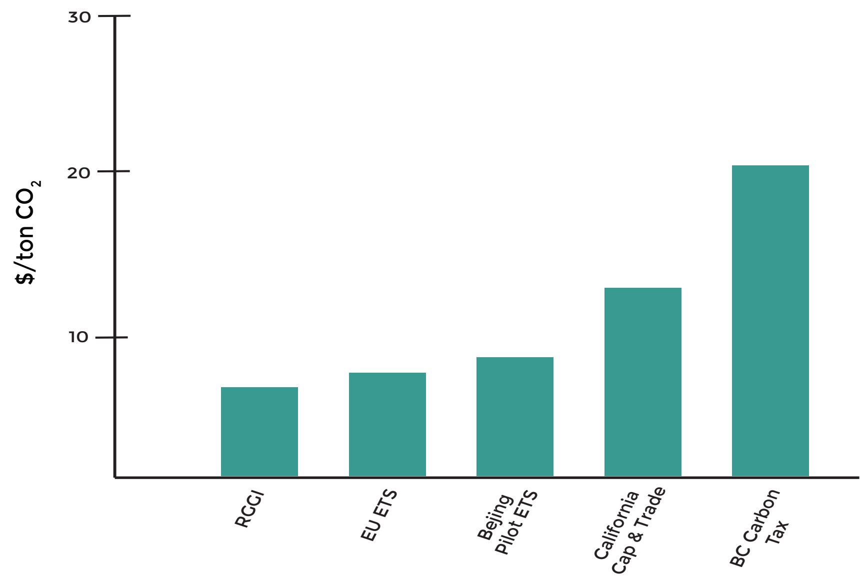
There are also few existing regulations to support the development of carbon removal solutions. In places where GHG regulation exists, the price of carbon is often too low to encourage the development of many carbon removal solutions (Figure 12). And in some cases, there are not protocols and offset standards that let carbon removal solutions participate in GHG regulatory schemes. For example, solutions like biochar do not have approved protocols to access California's cap-and-trade regime,[28] and bioenergy with CCS projects cannot get credit for negative emissions in the EU Emissions Trading Scheme.[29]

Figure 11. Learning Curve for Solar Photovoltaic Systems



Bringing down costs for solar PV took several decades as well as several landmark pieces of policy support, as mapped on a timeline in the graphic above. Adapted from Bloomberg New Energy Finance.[30]

Figure 12. Carbon Prices Too Low To Support Carbon Removal



Carbon prices only covered 12% of global emissions by the end of 2014 and most prices are too low to enourage the development of carbon removal solutions. While some landscape restoration programs are estimated to be competitive at current price levels, larger-scale industrial solutions (such as BECCS, DAC, etc.) require prices orders of magnitude higher to foster development.[31]

Outside of carbon regulations, there are no policies that explicitly mandate the deployment of carbon removal solutions. Energy and environmental programs that do provide some incentives for carbon removal solutions (e.g. loan guarantee programs, ecosystem conservation programs, and low-carbon fuel standards) are designed to encourage more technologically mature GHG abatement techniques and thus do not provide a strong enough incentive to encourage the development of carbon removal solutions.

Governments have also invested very little in research and development directly related to carbon removal. A 2010 report from the US Government Accountability Office (U.S. GAO) found less than $1 million per year in federal funding available for projects directly related to carbon removal—compared to an overall energy and climate R&D budget of $8 billion per year—with an additional $85 million either related to conventional mitigation strategies or fundamental scientific research related to carbon removal.[32] This lack of adequate federal R&D support is also seen in the wider CCS field, where funding has consistently been below industry-recommended levels.[33]

In the past several years, federal funding related to carbon removal has likely increased slightly. For example, the U.S. Department of Energy released a $3-million funding opportunity open to direct air capture systems,[34] and the U.S. Environmental Protection Agency has conducted a number of research projects around biochar.[35] However, no publicly available cross-cutting analysis has been conducted to quantify this funding since the U.S. GAO released its report in 2010.

Current industry and policy action for carbon removal is clearly insufficient for addressing the key uncertainties. Unless this lack of funding changes quickly, we risk not developing carbon removal solutions as swiftly as needed to curtail climate change.

ANALYSIS

SECTION 2

SECTION SUMMARY:

Philanthropies: well suited to kick-start the development of carbon removal solutions given policy/industry inaction

There are many reasons to suggest that philanthropies are well suited to catalyze action on carbon removal. Our investigation sought to understand the extent to which philanthropies were acting on this opportunity today and to identify strategies through which philanthropies can ignite action to develop carbon removal solutions. Two primary data sources were used: 1) a Foundation Center database that catalogs the number and size of philanthropic grants made in the U.S. over the past decade, and 2) interviews with more than 50 key stakeholders in the climate and philanthropic communities to understand why philanthropies are or are not funding carbon removal projects. The scope of this analysis was constrained to private foundations in the U.S. due to data limitations.

2.1 MOTIVATION

Philanthropies fill gaps, spur step-changes in tech, pursue cross-sector programming—just what carbon removal needs

In the past, philanthropies have had success in catalyzing action on critical technological and social issues. Philanthropies have a long tradition of "filling gaps, spurring step-changes in technology and pursuing programming that transcends both national boundaries and economic sectors."[36]

Philanthropies also are familiar with investments that cover long time horizons before realizing impact. This ability to measure success over greater periods of time compared to industry and government is especially pertinent when funding early investments in carbon removal, given that the full benefits of these investments will not be realized until decades in the future.

Because philanthropies can play a large role in kick-starting the development of carbon removal solutions, we set out to assess what philanthropies are and could be doing to support the carbon removal field. The remainder of this report summarizes our analytical approach, our findings, and where we see opportunities for philanthropies to have the greatest impact in the near future.

2.2 METHODOLOGY

To begin to understand the role that philanthropies are playing in carbon removal today, we analyzed a database of grants compiled by the Foundation Center. Once we had this data, we then interviewed dozens of key stakeholders in the philanthropic and climate change communities to get a better picture of what philanthropies thought about funding carbon removal solutions.

FOUNDATION CENTER DATA COLLECTION

A more in depth explanation of our data methodology can be found in Appendix C.

This report relies on data compiled from the Foundation Center Directory to understand how much and what type of funding philanthropies are providing to the carbon removal field today. The directory includes information on every grant disclosed in IRS information returns (Forms 990 and 990-PF) from 2008 to 2014.[37] The center also compiles information from foundation websites, annual reports, and other sources to provide a grant-maker name, recipient name, amount, year given, and a description for each grant whenever possible.

The Foundation Center database "tags" each grant with a broad category and allows users to search each grant using user-defined keywords. For this report, we relied on a subset of the database composed of grants tagged with the phrase "climate change" and a number of keywords related to carbon removal.

Because the Foundation Center database does not explicitly code for "carbon removal" (and because carbon removal can go by so many different names), we used a handful of definitions to estimate the likely range of funding for carbon removal solutions today. The first definition, labeled as "dedicated," was the most narrow and only counted grants that were tagged with the specific carbon removal technologies (listed in Section 2.2) and focused clearly on carbon sequestration (i.e. were not focused on the non-sequestration co-benefits offered by many approaches).

The second definition, labeled as "potential," included grants that were potentially (but not explicitly) aimed at carbon removal. This allowed for the inclusion of a larger number of biological carbon sequestration approaches that focused on the projects' non-sequestration co-benefits. For this purpose, we included agriculture techniques with direct links to carbon sequestration, particularly agroforestry and agroecology, but omitted other sustainable agriculture techniques with weaker links to carbon sequestration, such as organic or low- and no-till production.

.@carbonremoval used @FoundationCenter data to understand historic philanthropic involvement in carbon removal

We then considered a third, most-inclusive definition for carbon removal, labeled "pathway." This definition included grants that could potentially provide a pathway for developing carbon removal approaches in the future, including those directed towards bioenergy, fossil energy with CCS, and avoided deforestation. This broad definition was designed to capture as much of the work potentially related to carbon removal as possible.

DATA LIMITATIONS:

It is important to note the limitations of our data collection methodology. Categorizing grants was difficult considering the manual nature of reading through short grant descriptions, which may not be representative of the true intention or end result of many grants. In addition, data limitations did not allow us to separate out possible re-grants or support for carbon removal that may be hidden within grants towards general operating funds of environmental non-profits.
Further, interviews did not come from a random sample of all philanthropic organizations and stakeholders, as we only requested interviews with stakeholders in climate change philanthropies and from philanthropies with goals auxiliary to climate change.

SCOPE:

For the purpose of this report, we focused on philanthropic foundations within the United States that donated to climate change mitigation or adaptation. Internationally based philanthropies were not considered, largely due to constraints resulting from a lack of available data. Nevertheless, an extension of this analysis that includes these additional philanthropic stakeholders would likely provide a valuable complement to this initial analysis.

INTERVIEWS

To complement our analysis of the Foundation Center database, we conducted a series of interviews with philanthropies and experts in the carbon removal field to understand philanthropic motivations and uncertainties in funding for carbon removal. In total, we interviewed 50 individuals from different organizations, ranging from philanthropists, philanthropic advisors, and carbon removal researchers (see Appendix A for a breakdown of the interview candidates). Each participant was given a similar set of prompts that focused on three main types of questions: organizational- or mission-related questions, funding strategies, and specific carbon removal subject matter knowledge (see Appendix B for interview prompt details). These types of questions were used to understand how philanthropies think about carbon removal today and why they are or are not investing in these solutions.

What do philanthropies think about carbon removal? @carbonremoval interviewed 50+ experts to find out.

Pictured: Founder of GreenSand, Eddy Wijniker, among bags of olivine fertilizer designed to sequester CO_2

Source: GreenSand

RESULTS

SECTION 3

SECTION SUMMARY:

- *< 0.4% of climate philanthropy between 2008-2014 was dedicated to carbon removal*

- *High costs & uncertainties have discouraged potential funders from making grants to carbon removal projects*

Our analysis of data from the Foundation Center shows that philanthropies have provided negligible funding to carbon removal to date, amounting to less than 0.4% of total climate change funding between 2008 and 2014. Interviews reveal that philanthropies have historically been hesitant to invest in carbon removal due to the high GHG abatement costs of carbon removal projects compared to other mitigation approaches and because they have not seen carbon removal as an important complement traditional to GHG abatement strategies.

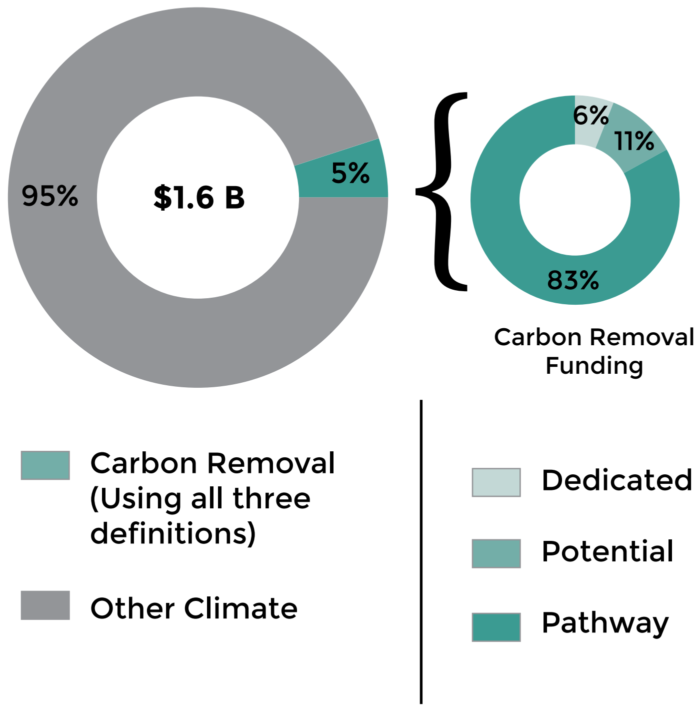
3.1 KEY FINDINGS: DATA ANALYSIS

Our analysis of the Foundation Center database reveals that only a very small portion of philanthropic funds dedicated to fighting climate change supports carbon removal solutions. The data show that from 2008 to 2014, philanthropies donated only an average of **$0.8 million per year** ($5.3 million total) in grants to carbon removal projects (0.3% of total climate change giving) under the "dedicated" definition. This amount increases to an average of **$2.3 million per year** ($15.8 million total) when including grants with the potential for carbon removal (1% of total climate change giving), and to an average of **$13 million per year** ($90.6 million total) when expanded again to include grants that could provide pathways for carbon removal in the future (5% of total climate change giving) (Figure 13 and 14).

Figure 13. Carbon Removal Funding at a Glance

	Average Giving Per Year	Percentage of Climate Change Philanthropy	Total Giving from 2008-2014
Definition 1 - Dedicated	**$0.8 million/year**	**0.3%**	**$5.3 million**
Definition 2 - Potential	$1.5 million/year	0.7%	$10.5 million
Definition 3 - Pathway	$10.7 million/year	4%	$74.8 million
Cumulative	$13 million/year	5%	$90.6 million

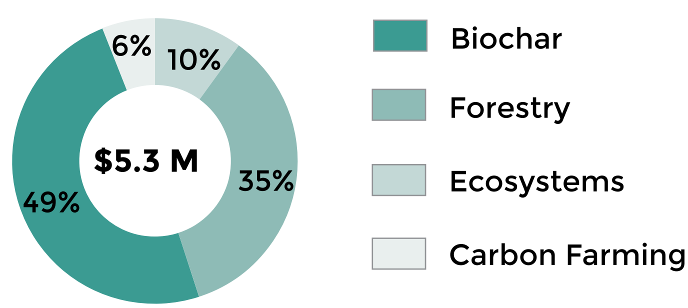
Figure 14. Percentage of Climate Funds to Carbon Removal



DEFINITION 1 - DEDICATED

Using the narrowest interpretation of carbon removal funding, our analysis shows that philanthropies have contributed an average of $0.8 million in grants towards carbon removal annually (Figure 15: A total of $5.3 million over 46 grants were identified in the analysis timeframe). Biological carbon removal approaches (biochar, carbon farming, reforestation/afforestation, and ecosystem restoration) accounted for all of this funding, as there were no grants in the database that included keywords for bioenergy with carbon capture and storage, mineral capture, or direct air capture.

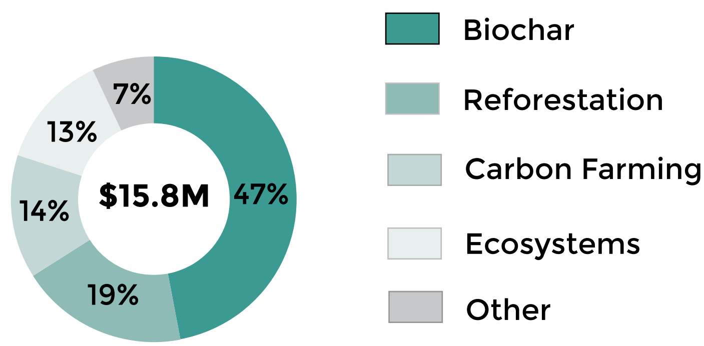
Figure 15. Defintion 1: "Dedicated" Carbon Removal Funding Breakdown



DEFINITION 2 - POTENTIAL

Widening the definition of carbon removal funding to include grants potentially supporting, but not primarily motivated by, carbon removal, the data show that philanthropic funding jumps to an average of $2.3 million per year (Figure 16: $15.8 million across 156 total grants in the analysis time frame). Funding for biological methods still comprises all of the funding. Biochar leads the funding distribution, with about 50% of carbon removal funds allocated to its development. Carbon sequestering agriculture becomes an increasing percentage of funding once this definition is expanded, suggesting that funding to carbon farming may often be motivated by co-benefits rather than carbon sequestration.

Figure 16. Defintion 2" "Potential" Carbon Removal Funding Breakdown



Note: Includes "dedicated funding"

DEFINITION 3 - PATHWAY

Under the third and most expansive definition of carbon removal (which includes grants that could help pave the way for carbon removal), the data show an additional yearly average spending of $10.7 million, bringing the total associated carbon removal funding to an average of $12.9 million per year (Figure 17: a total of $90.6 million over 7 years). These additional projects (including bioenergy, fossil CCS, and avoided deforestation) can pave the way for carbon negative technologies by furthering technology, improving communications, and developing the regulatory framework needed to support carbon removal solutions (Figure 18).

Figure 17. Defintion 3: "Pathway" Carbon Removal Funding Breakdown

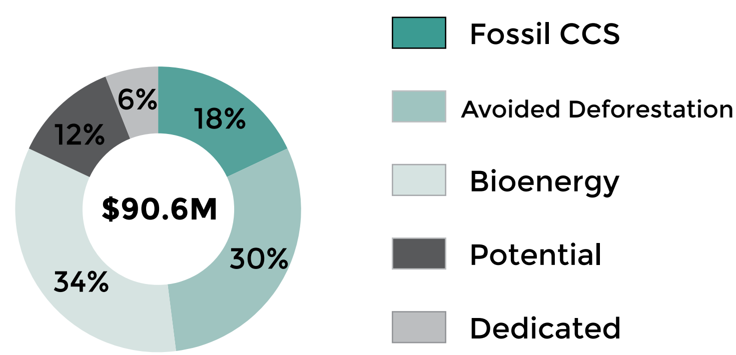


Figure 18. Funding for “Pathway” Technologies & Their Connection to Carbon Removal

Technology	Cumulative Funding (over 7 years)	Connection to Carbon Removal
Fossil CCS	$16.3 million	CCS, even if fossil, can pave the way for direct air capture and bio-energy + CCS by improving capture technology and answering key questions around geologic storage.
Avoided Deforestation	$27.7 million	While avoided deforestation does not provide any additional sequestration, it can help improve knowledge on forest management and biological sequestration.
Bioenergy	$30.8 million	Improvements in bioenergy generation and life cycle accounting for bioenergy are important to ensure that bioenergy + CCS is truly carbon negative.
Total	$74.8 million	

3.2 KEY FINDINGS: INTERVIEWS

Philanthropies have not seen carbon removal as a complement to lower-cost GHG abatement solutions

Some philanthropies do fund carbon removal related projects, but are motivated primarily by co-benefits

Philanthropic funding for fossil+CCS projects: not motivated by link to negative emission energy

Interviews with foundation staff and other key stakeholders revealed a number of insights into why philanthropies have and have not made grants to support carbon removal. First, the majority of interviewees were familiar with carbon removal solutions but said that their organizations had not funded projects because of the high costs and uncertainties surrounding individual carbon removal options. Interviewees also spoke little of the urgency or added value of a portfolio of carbon removal solutions. Instead, carbon removal projects were largely judged as an inferior alternative to more traditional GHG abatement projects—especially when compared to renewable energy, energy efficiency, and avoided deforestation—because carbon removal solutions offered lower GHG abatement per dollar spent.

Philanthropies that have funded carbon removal and related projects said that many of these grants were motivated by auxiliary removal goals. In fact, most of the grants to biological carbon removal projects were primarily funded by the agriculture, economic development, or general environment divisions of philanthropies—not the climate divisions. Many of these projects were motivated primarily by climate adaptation, ecosystem services, and/or economic development benefits they provide in addition to their carbon removal benefits.

The small cluster of philanthropies that did support high-level policy work for large-scale CCS was motivated largely by the belief that CCS technology held the most potential as a fossil energy GHG emissions abatement technology—not as negative-emissions carbon removal solutions. This group viewed negative-emissions energy systems like BECCS and DAC as less urgent priorities than capturing CO_2 at existing fossil-fired systems.

Pictured: Biochar after the pyroloysis process. Biochar has the potential to store CO_2 that would have previously been released during plant decomposition.

Source: K.salo.85 via Wikimedia

BEYOND CARBON NEUTRALITY

SECTION 4

SECTION SUMMARY:

How can philanthropy move beyond carbon neutrality? 1) elevate the issue, 2) spur RD&D/innovation, and 3) support policy

The historic grant-making approach pursued by climate philanthropies is likely insufficient to address the opportunities and challenges surrounding carbon removal. When philanthropies do start funding projects related to carbon removal, there are a number of goals toward which they can direct their funding to maximize impact, including:

1. Elevating the conversation on carbon removal in industry and policy circles
2. Building the case and advocating for research, development, and demonstration (RD&D) and technology innovation for a broad portfolio of carbon removal solutions
3. Identifying and advocating for appropriate policy mechanisms to support carbon removal

Philanthropic grants aimed toward these goals can have high leverage by helping to unlock additional industry and government funding to commercialize carbon removal solutions.

4.1 THINKING BEYOND NEUTRALITY

The grant-making approaches that philanthropies have pursued in the past are likely insufficient to support the development of carbon removal solutions in the future. First, continuing to judge carbon removal projects against more mature GHG abatement solutions can lead to under-investment in carbon removal solutions. The gap in costs and uncertainties between GHG abatement and carbon removal solutions will grow as long as funding only supports GHG abatement projects. This can lead to a self-reinforcing cycle in which carbon removal solutions will not get the support they need until most GHG emissions abatement options have been exhausted. If this situation occurs, carbon removal systems will struggle to reach scale as quickly as needed to protect from budget overshoot.

Secondly, a continued focus on funding carbon removal projects based primarily on their co-benefits is likely insufficient to catalyze growth in the field. The co-benefit-focused approaches neglect some of the larger-scale carbon removal solutions that have fewer co-benefits but could still offer larger climate change mitigation potential. In addition, co-benefit driven projects tend to focus less on life-cycle CO_2 accounting, making it difficult to understand the true carbon impacts of these projects.

Finally, continuing to focus only on fossil CCS is likely insufficient to build the political coalitions needed to support carbon-negative energy systems in the future. CCS is likely to remain conflated with the idea of prolonging "business-as-usual" energy systems until CCS project developers clearly commit to a transition to negative-emissions CCS in the future. Ways to credibly commit to this trajectory include policies to promote co-firing biomass at fossil energy CCS projects and/or developing dedicated BECCS projects as part of a larger portfolio of CCS projects.

4.2 OPPORTUNITIES FOR ACTION

There are a number of high-leverage actions that philanthropies can take today to advance the development of carbon removal solutions.

1. ELEVATING THE CONVERSATION ON CARBON REMOVAL

While academics are clear that carbon removal is likely to play a critical role in curtailing climate change, industry and policy discussion of the topic remains in its infancy. Philanthropies can help kick-start the conversation on how industry and policy can integrate carbon removal into their climate action strategies today.

To start, developing effective communications materials designed for media, industry, and policy audiences can help bring awareness to the opportunities and challenges facing carbon removal solutions. For example, philanthropies can dedicate portions of their existing communications and education efforts to include initiatives that help make the case for urgent action on carbon removal.

Pictured: Carbon Engineering direct air capture facility in Squamish, British Columbia
Source: Carbon Engineering

"Communications is at the very center of successful policy engagement for these foundations."

– USC Report: The Communications Supercharge

Communications capacity-building for grantees related to carbon removal can also help elevate the issue in the climate conversation. Practitioners working directly on projects with carbon removal potential can help advance the overall conversation by sharing their stories and helping industry and policy stakeholders envision the types of strategies that can contribute to a portfolio of carbon removal solutions in the future.

Finally, creating strategies to support the development of carbon removal solutions in conjunction with stakeholders from across sectors can also have a large impact. Dedicated events such as workshops and conferences can engage industry, policy, and NGO communities in collaborative efforts to tackle the uncertainties surrounding carbon removal solutions. In the past, philanthropies have found that co-creating initiatives with key stakeholders can help subsequent grant-making initiatives generate the largest impact while simultaneously increasing the saliency of the issues at hand.[38]

Communications Case Study:

The Center on Philanthropy and Public Policy report The Communications Supercharge highlights the influence philanthropic communications can have through the following example:

"Senior VP at Robert Wood Johnson Foundation wrote a blog post in the Huffington Post explaining why the Congressional Budget Office (CBO) should 'score' costs of and savings from health prevention programs over a 20-year period rather than its standard 10 years. CBO had long been dug in to a 10-year time frame. The blog was widely read and re-tweeted, resulting in interviews with and quotes in the Wall Street Journal, Bloomberg and AOL Financial News and many discussions with CBO. Several weeks later, CBO announced it would score prevention sections of health reform legislation using a 20-year window." [39]

2. BUILDING THE CASE FOR RD&D AND TECHNOLOGY INNOVATION

Before carbon removal solutions reach scale, uncertainties regarding each approach will need to be addressed through RD&D programs. Philanthropies can build the case and advocate for increased government and industry spending on RD&D and technology innovation for carbon removal solutions in a number of ways.

For one, providing funding for technology roadmaps can help industry and government leaders understand where to place investment and legislative priority. Philanthropies can unlock significant funding by partnering with scientific and technical organizations to build independent assessments of the specific RD&D needs of the carbon removal field. It is also important to couple this technical analysis with education and outreach aimed at policymakers and industry executives. Only through clear communication about the importance of such RD&D spending can technical analysis translate into industry and policy action, in turn unlocking orders of magnitude more funding for RD&D than the philanthropy could have supported themselves.

As an example, philanthropies have collaborated with the U.S. DOE on addressing early-stage finance gaps and supporting innovative energy policies over the past few years. Through this collaboration, philanthropies and several federal agencies have worked to release the *Guide to Federal Financing for Energy Efficiency and Clean Energy Deployment*, helping local and state governments, along with their private sector partners, deploy clean-energy systems across the country.[40]

In addition, philanthropies can pursue alternative grant-making approaches by directly funding research and technology innovation. Direct investments in science and technology research projects targeted to address "bottleneck" uncertainties can unlock additional funding by providing evidence of the sustainable scale potential of carbon removal solutions. Philanthropies can avoid large expenditures on direct research by partnering with existing projects that have been funded for non-climate reasons (e.g. ecosystem restoration, sustainable agriculture, etc.) to fund science that supports more effective lifecycle carbon accounting and through public-private partnerships for technology RD&D initiatives. Grants going to support innovation through contests like those hosted by the Virgin Group and the XPRIZE Foundation, as well as climate incubators such as the EU's Climate Launchpad contest, can also provide the incentives for entrepreneurs to focus their efforts on developing products that serve early markets for carbon removal.

3. DEVELOPING APPROPRIATE SHORT-TERM POLICY MECHANISMS

In the long run, high carbon prices and/or stringent GHG regulations are likely to support the commercialization and deployment of carbon removal solutions. Without such incentives in the short and midterm, carbon removal solutions will need complementary policies to foster their growth and development. Philanthropies can work with experts across sectors to identify the most appropriate policy mechanisms for supporting carbon removal in the future. These policy experts can also help identify the governing structures required to coordinate activity across the wide range of organizations that hold carbon removal potential.

MEASURING SUCCESS:

It is essential for philanthropies to measure the success of their efforts with appropriate metrics tailored to the nascent nature of the carbon removal field.

In the short term, grant-making efforts around carbon removal can be judged by:
- The number of governments and companies that commit to negative emissions targets
- The number and strength of regulations and policies enacted to specifically increase demand and deployment for carbon removal solutions
- The amount of investment in RD&D in carbon removal
- The number of carbon removal projects and companies
- The number of dialogues/events hosted
- The amount and quality of media coverage

CONCLUSION

Numerous opportunities exist for philanthropies to ignite action to develop carbon removal solutions today. These actions can generate significant leverage by influencing industry and policy leaders to unlock additional investment in carbon removal field.

While all proposed carbon removal strategies are uncertain to some extent, philanthropies increasingly understand that the most risky strategy around carbon removal is to do nothing at all.

The coming years will prove critically important in the fight against climate change. Philanthropies can ensure that we have the necessary solutions to stabilize the climate and ensure prosperity for decades to come, but only with swift action today to ensure carbon removal solutions develop appropriately.

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APPENDICES

APPENDIX A:

Of 50 Total Interviews:

- 28 work for foundations
- 8 are academics
- 12 work for grant-receiving NGOs
- 2 are independent experts

APPENDIX B:

Philanthropic interviewees were asked a mix of the following questions. Interviews were conversational, so question order was partially determined by their answers to previous questions. That is, if an interviewee revealed the answer to a subsequent prepared question in the course of conversation, that subsequent question was skipped (or modified and/or clarified). The order and exact phrasing of questions asked was also supplemented with information publically available about the interviewees' organizations.

Interviewees that did not work for philanthropies were asked similar questions about carbon removal and climate change, but were asked about their experience working with philanthropies (instead of questions specifically related to philanthropic missions).

Mission-Related Questions:

1. Can you please elaborate on how fighting climate change specifically fits your mission and goals? (if the foundation is not specifically climate change related)
2. What do you consider success in the fight against climate change? How has this affected your grant-making strategy?
3. What is the role of philanthropy (as opposed to industry/government) broadly in fighting climate change?
4. What other non-climate factors are most important for when funding climate-related projects? (ex. geography, addressing inequalities, other environmental co-benefits, etc.)

APPENDIX B (cont.):

Tactics Questions:

1. Which of the following strategies do you fund? Why?
    a. Policy/advocacy
    b. Public education and engagement
    c. R&D
    d. Project finance
    e. Other (please state)
2. How do you measure impact of these various projects?
3. How do you prioritize specific projects?
4. Have you funded or considered funding any carbon removal projects in the past?
    a. If yes:
        i. Which categories?
        ii. Why did you chose those?
    b. If no:
        i. Why not?
        ii. What information would convince you that you should focus on carbon removal? What changes in the research/deployment landscape would make you re-evaluate your lack of action in this area?

APPENDIX C.

Grants were compiled from the Foundation Center Directory. The Foundation Center Directory includes information on every grant disclosed in IRS information returns (Forms 990 and 990-PF) from 2008 to 2014. The Foundation Center database "tags" each grant with a broad category and allows users to search each grant using user-defined keywords. For this analysis, we relied on a subset of the Foundation Center database composed of grants tagged with the phrase "climate change" and a number of related keywords.

Grants were included in the analysis if they included one of the following key terms in their grant description: carbon sequestration, environment, agriculture, sustainable agriculture, biochar, forest, forestry, reforestation, CCS, emissions, negative emissions, climate, sequestration, sustainability, agrobiodiversity, agroecology, carbon, energy, ecosystem restoration, carbon farming, bioenergy, energy, biofuels, carbon capture and storage, carbon negative, farm, and enhanced weathering. From there, grants were allocated to one of the three categories (defined in Section 2.2) or considered irrelevant to the purpose of this report.

APPENDIX C (cont.):

In this analysis, percentages were calculated by summing relevant categories and subsequently dividing grants by the total $1.6 billion given to climate change from philanthropies. Although not all of the grants were explicitly or primarily motived by climate change (according to the Foundation Center categorization), using this methodology allows us to conservatively estimate the involvement of philanthropies in carbon removal in comparison to their other granting priorities.

Due to data limitations, we were unable to distinguish between original granting and re-grants. Further, we recognize that the data limitations in the current methodology might not capture efforts related to carbon removal within grants given toward general operating funds.

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