RMI

A Government-Led Advance Market Commitment for Carbon Removal

Discussion Paper / October 2025

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About RMI

Rocky Mountain Institute (RMI) is an independent, nonpartisan nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to secure a prosperous, resilient, clean energy future for all. In collaboration with businesses, policymakers, funders, communities, and other partners, RMI drives investment to scale clean energy solutions, reduce energy waste, and boost access to affordable clean energy in ways that enhance security, strengthen the economy, and improve people's livelihoods. RMI is active in over 50 countries.

Contents

Executive Summary

What carbon removal offers the world

- Carbon removal is **human activity that removes CO_2** from the atmosphere and durably stores it in geologic, terrestrial, or ocean reservoirs, or in products.[1]
- Carbon removal, alongside deep decarbonization efforts, will be **needed at the scale of gigatons (Gt) per year by midcentury** to stabilize the climate and then enable drawdown of excess emissions that otherwise would remain in the atmosphere for centuries.
- Done right, carbon removal **brings numerous other benefits**: creating good, meaningful jobs; productively reusing agricultural, industrial, and mining waste; mitigating wildfire risk; and restoring vital ecosystems, including forests, oceans, and soils.

The carbon removal gap

- On the order of **100 megatons per annum (Mtpa)** of carbon removal, at least, across a diverse portfolio of approaches will be needed by 2035 to have a chance of reaching midcentury Gt-scale targets, requiring **funding of approximately $20 billion per year** by 2035 for innovation and early deployment.
- Many carbon removal approaches are **early in development and not yet widely deployed** because of high initial costs and technical uncertainties.
- **Voluntary corporate demand** for carbon removal has been catalytic for the field to date and is growing but is likely insufficient to achieve $20 billion per year by 2035 alone.
- Dozens of governments have made promising starts to support carbon removal, but **significant new policy is needed** to close the gap between where the voluntary market is likely headed and the need by 2035.

Why a government-led advance market commitment (AMC) for carbon removal

- Government-led AMCs efficiently **use taxpayer funding to catalyze innovation** and early deployment of important public goods, as demonstrated by such examples as vaccines.[2]
- An AMC is well suited for carbon removal because it can be **designed to achieve desired outcomes** (i.e., how much carbon removal at what price per ton), then private industry can determine the technology mix that best delivers these outcomes.

- An AMC led by **multiple governments can also be an efficient mechanism** to catalyze more private voluntary purchasing of removals by:
    - Sending a credible signal that governments are committed to working together to build a larger global market for carbon removal in the long term
    - De-risking and facilitating offtakes by allowing private buyers into purchases where government procurement is "first in the door"
    - Providing the voluntary market with reference points on standards and practices considered fit-for-purpose by governments
- When successful, an AMC will enable carbon removal technology to mature to the point where **carbon markets and related policies can scale** the industry alongside deep decarbonization efforts to achieve midcentury climate targets.
- By launching an AMC, **governments could derive unique benefits** such as gaining visibility into the frontier of carbon removal development; positioning themselves centrally in the design of standards, markets, and technologies for a global industry; and building internal regulatory and diplomatic capabilities in carbon removal.

Goals of this discussion paper

- This discussion paper provides a **menu of options** for the design of a carbon removal AMC with the aim of **sparking and informing a process** by which government, civil society, and industry stakeholders co-create an AMC best suited to the needs of the involved governments and the carbon removal sector.

Section 1: Introduction

While the world must do all it can to reduce emissions as quickly as possible, carbon removal will be needed at the scale of billions of tons per year by midcentury. It will be challenging to build a carbon removal industry this large in such little time, so it is essential for governments to proactively stimulate innovation, early commercialization, and policy development for a portfolio of carbon removal solutions in the near term. A government-led advance market commitment (AMC) for carbon removal offers not only a high-impact tool for stimulating the industry in this way but also unique benefits to the governments that choose to lead it.

1.1 Carbon removal

Carbon removal is human activity that removes CO_2 from the atmosphere and durably stores it in geologic, terrestrial, or ocean reservoirs, or in products.[3]

Carbon removal is human activity that removes CO_2 from the atmosphere and durably stores it in geologic, terrestrial, or ocean reservoirs, or in products. It includes a range of approaches, many of which are new and are being developed at a rapid pace.

Achieving and going beyond net zero is essential to reversing global warming trends and avoiding the most severe impacts of climate change.[4] If climate targets are not met, the world will face severe economic and health impacts. The Swiss Re Institute estimates that if no mitigating actions are taken on climate, the global economy could be 18% smaller in 2050 than a world without warming; however, if Paris Agreement targets are met, the global economy could be 4% smaller than a world without warming.[5] Additionally, the World Health Organization estimates climate change will cause about 250,000 additional deaths per year between 2030 and 2050.[6]

Carbon removal is the only tool available for addressing residual emissions and is therefore key to achieving net-zero and net-negative emissions. Thus, along with emissions reductions, carbon removal will be needed to limit global temperature rise and reverse any overshoot of temperature targets.[7] The scale of carbon removal needed is significant, with billions of tons per year of carbon removal estimated as being necessary by 2050.[8]

To fulfill its role in climate action, the carbon removal industry needs to make progress on many fronts over the next decade, including:

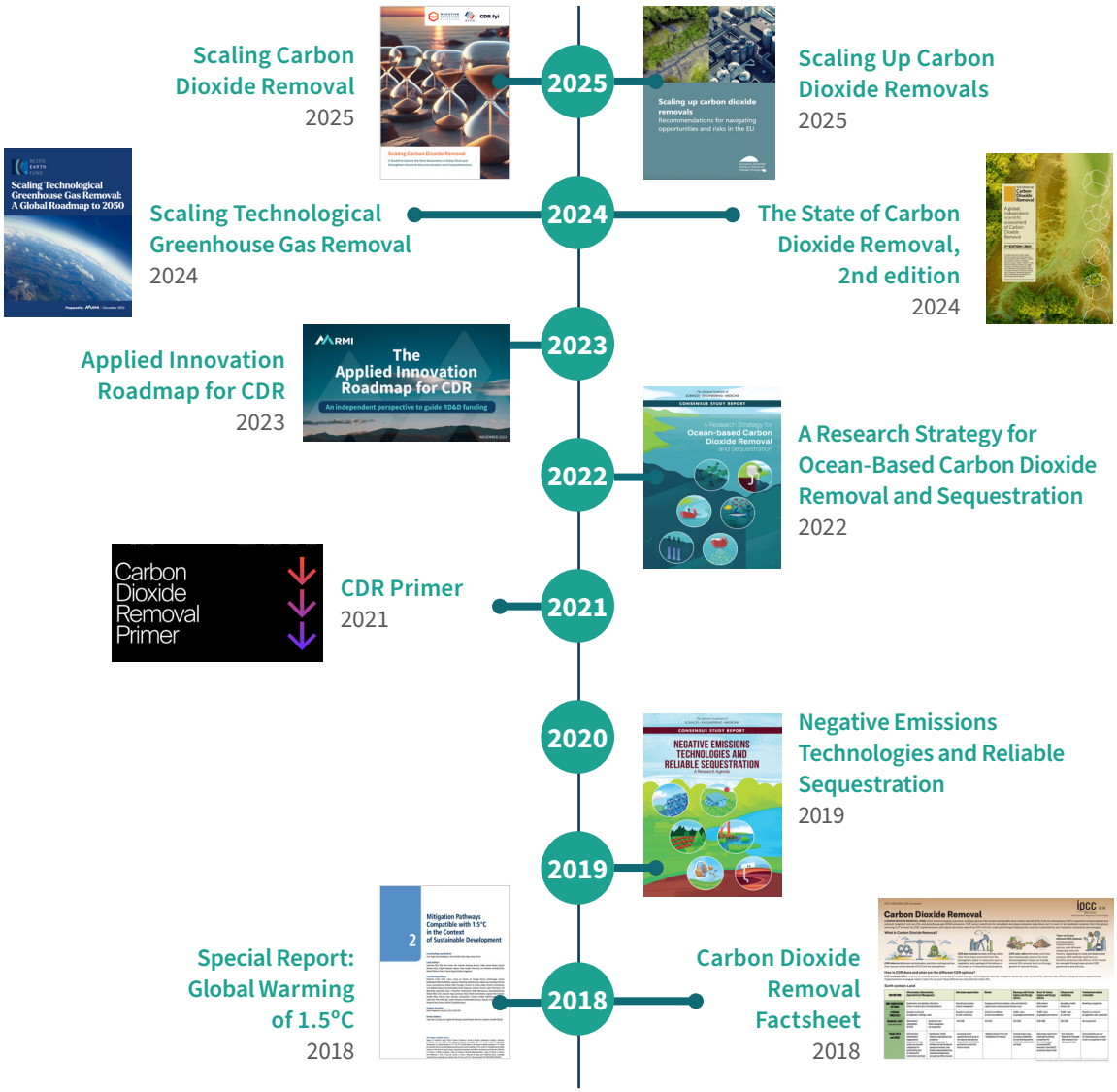
- Developing a portfolio of approaches
- Achieving sufficient deployment

- Filling other critical gaps in scaling carbon removal, including shared infrastructure build-out, measurement development, standards creation, public acceptance, and others

The reports and other resources in Exhibit 1 provide additional details on these points.

This progress will require well-coordinated government support, and in parallel with other initiatives, a government-led AMC for carbon removal is a specific intervention particularly well suited to advancing these outcomes.

Exhibit 1 **Resources on carbon removal**



RMI Graphic.

1.2 AMCs in health and in carbon removal

An **advance market commitment (AMC)** is a financial mechanism designed to stimulate the development and deployment of new technologies by guaranteeing a future market for them.

An AMC is a financial mechanism designed to stimulate the development and deployment of new technologies by guaranteeing a future market for them. In essence, an AMC is a promise by governments or other entities to purchase a specific amount of a product or service once it becomes available. This commitment stimulates investment by developers, investors, and lenders and the development and deployment of innovative solutions.

AMCs have been successfully used in the healthcare sector to accelerate the development of vaccines, such as for pneumococcal disease.[9]

AMCs have also been used by the private sector for carbon removal; for example, Frontier Climate is a $1 billion commitment by several large corporations to purchase carbon removal that is durable for 1,000 years or more, and Symbiosis is a commitment by a different group of companies to contract up to 20 million tons of "nature-based carbon removals" by 2030.[10]

Future demand for carbon removal is uncertain. By guaranteeing a market for carbon removal, the Frontier and Symbiosis AMCs have provided certainty and attracted private investment into innovation and early deployments for carbon removal technologies.

AMCs can play a key role in spurring innovation, which can lead to cost and resource efficiency for technologies, including carbon removal approaches. Additionally, early deployments paid for through AMCs validate real-world performance and set precedents for further deployments. See Exhibit 2 for examples of AMCs.

Exhibit 2 Resources on and examples of AMCs

RMI Graphic.

1.3 Unique benefits to leading governments

Governments that decide to lead together on an AMC would maximize the odds that carbon removal is successfully developed.

The successful development of carbon removal will give governments a valuable tool to better manage climate and security risk, while deriving a number of unique benefits. These could include gaining visibility into the frontier of carbon removal technology development and performance, shaping emergent global carbon removal standards, building internal capabilities in carbon removal, and strengthening working relationships with other governments. Beyond these strategic benefits, governments involved in an AMC can potentially provide direct benefits to their constituents, including jobs, economic development, improved infrastructure, and cleaner air, water, and soils.

Governments have a unique opportunity to add valuable new tools to their toolkit; improve their security, competitiveness, and prosperity; and deliver direct benefits to their constituents through leadership on an AMC for carbon removal.

1.4 The rest of this discussion paper

The rest of this discussion paper examines how a government-led AMC could build on existing carbon removal policies and AMCs, accelerating the carbon removal industry in the next critical decade.

Specifically, it lays out the motivation for increasing support for the carbon removal industry, why a government-led AMC is needed now, design considerations and implications, benefits derived from an AMC, and specific suggested follow-on actions.

This discussion paper aims to spark a collaborative design effort among interested stakeholders and give the carbon removal industry the kick-start it needs to play its role in climate action. It aims to inform and guide decision makers in governments, catalytic philanthropic actors, and other interested parties in designing an AMC that can be deployed at a global scale.

Section 2: The Carbon Removal Gap

Section at a Glance

- **On the order of 100 megatons** per annum (Mtpa) of carbon removal, at least, across a diverse portfolio of carbon removal approaches will be needed by 2035 to have a chance of reaching midcentury targets, **requiring funding of approximately $20 billion** per year by 2035.
- **Funding and deployment, to date, are inadequate** overall and unequally distributed across carbon removal approaches. Under current conditions, potential future funding and deployment are likely insufficient to generate the portfolio of gigaton-scale-ready solutions that will be needed by 2035.

2.1 The funding gap

2.1.1 Rapid scaling is needed leading up to midcentury

Billions of tons per year, or gigatons per annum (Gtpa), of carbon removal will be needed by midcentury to keep the world on track to minimize the negative impacts of climate change.[11]

It will be challenging to build an industry of this size in this little time, so it is imperative to start immediately. For example, wind energy generation increased more than 10 times from 2008 to 2023 at a rapid rate of 17% annualized growth. Over the same period, solar energy generation increased more than 130 times at a breathtaking rate of 39% annualized growth.[12] Even if carbon removal were able to grow from 2035 to 2050 at a rate similar to solar energy's historic 39%, which is extremely unlikely, deployment across a portfolio of carbon removal approaches on the scale of **100 Mtpa, at least, will be needed by 2035** to maintain the possibility of achieving midcentury targets (see *Appendix 3* for analysis).

> **Billions of tons per year, or gigatons per annum, of carbon removal will be needed by midcentury to keep the world on track to minimize the negative impacts of climate change. It will be challenging to build an industry of this size in this little time, so it is imperative to start immediately.**

The funding needed for carbon removal to reach 100 Mtpa in 2035 and Gtpa-scale in 2050 would be substantial but likely affordable for wealthy countries and private-sector actors based on historical spending on clean energy innovation.[13] Assuming average prices of $200 per ton in 2035 and $100 per ton

in 2050, carbon removal **would require at least $20 billion per year by 2035**, and at least $100 billion per year by 2050 (depending on the ultimate scale needed). In comparison, the world spends roughly $250 billion per year on waste management and $2.5 trillion per year on defense.[14]

Some carbon removal approaches generate benefits beyond carbon removal itself, and some of these benefits can be monetized.[15] These secondary benefits and markets can help support carbon removal innovation and cost reductions. But, for multi-Gtpa-scale carbon removal markets, public policy and regulation designed primarily to reduce the costs of carbon removal as much as feasible will be needed.

2.1.2 Innovation and maturation are needed in the next decade

In the next decade, it will be important to **support a portfolio of approaches** because no single approach can be expected to meet the full need for carbon removal at midcentury. All approaches, for example, afforestation, bioenergy with carbon capture and storage (BECCS), direct air capture (DAC),[i] and others, will face challenges scaling to multiple Gtpa, such as competition for key inputs (e.g., land, sustainable biomass, clean energy) and bottlenecks in permitting, infrastructure development, and workforce development. Employing a variety of carbon removal approaches will ease pressure on these key inputs and enable more geographies to participate in supplying carbon removal.[16] Exhibit 3 (next page) illustrates the many known carbon removal approaches.

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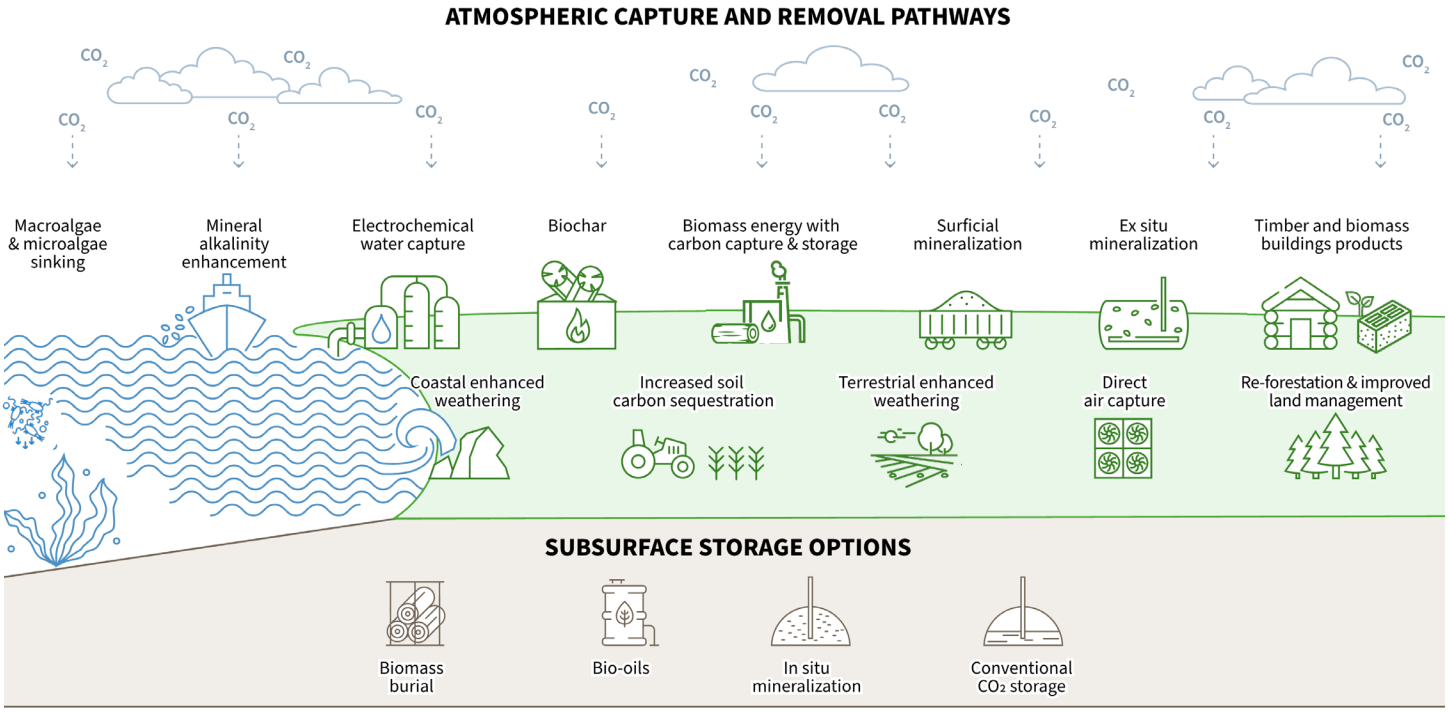
i **Afforestation is defined** as the conversion to forest of land that historically has not contained forests. **BECCS is defined** as the thermal or biochemical conversion of biomass to generate electricity or fuels and produce CO_2 that is captured with carbon capture and storage technology. **DAC** is defined as the use of machines to capture CO_2 from the atmosphere in a concentrated stream.

For an approach to have a chance of reaching 1 Gtpa in 2050, even if very rapid scaling is achieved, it is likely that at least 10 Mtpa per approach would need to be deployed by 2035 (*Appendix 3)*. Approaches that have reached this threshold are likely to be the ones that will be relied on at scale at midcentury. There has been a recent boom in innovation in carbon removal, but very few approaches have been deployed at the 10 Mtpa scale or are on track to do so.[17] Thus, more innovation should be incentivized and support for emerging approaches (less than approximately 10 Mtpa deployed) should be increased between now and 2035 so a portfolio of approaches will be ready to scale.

There are other important arguments for a portfolio approach:

- It recognizes that, although we need to move quickly to reach 2050 scaling goals, we are also early in the problem-solving process and have limited information and confidence about how carbon removal will evolve.
- It enables more people to participate in the search for solutions, unleashing more innovation, more positive spillover effects, and surprises to the upside.
- It enables a wider range of communities to participate in the economic opportunities from carbon removal, creating more benefits from the technologies and broader political support.

Exhibit 3 Carbon removal approaches



RMI Graphic. Source: RMI, "**From Trees to Tech and Beyond**"

2.1.3 Support to date is inadequate

Significant research, development, demonstration, and deployment of carbon removal are occurring, but **funding to date has been inadequate overall and unequally distributed across carbon removal approaches**. Therefore, some approaches are more ready than others to play a significant role by midcentury.

Mature approaches like afforestation, reforestation, and revegetation are currently deployed on a scale of tens of millions of tons per year and generate credits that are retired in multiple voluntary and compliance systems.[18] For example, greater than approximately 10 Mtpa in voluntary carbon market credits have been issued since 2020 in these approaches,[19] and California's Cap-and-Trade Program includes both improved forest management and reforestation projects.[20]

In contrast, funding of emerging, mostly high-durability carbon removal approaches is far below the level that will be needed in 2035 and the level needed to drive the cost reductions that would enable deployment at scale. To date, approximately $25 billion in total funding has gone into emerging carbon removal approaches across investments, subsidies, and purchases; approximately 26 megatons (Mt) total of high-durability carbon removal has been delivered or is contracted to be delivered; and as of 2024, approximately 1 Mtpa of high-durability carbon removal is occurring.[21]

A key reason for this lack of deployment of high-durability carbon removal approaches is the unwillingness of most buyers to pay the relatively higher prices for these types of carbon removal, especially because there is a lack of a clear mandate to do so.[22]

Additionally, even this low level of support paints a potentially too optimistic picture for these carbon removal approaches. The voluntary purchasing that is driving high-durability carbon removal demand is dominated by just a few large corporate buyers.[23] Few compliance systems incorporate high-durability carbon removal; for example, Japan's Green Transformation Emissions Trading System (GX-ETS) allows carbon removal credits,[24] and California's Low Carbon Fuel Standard regulation includes DAC as an eligible pathway,[25] but little purchasing has occurred to date.

2.1.4 Outlook is insufficient

Additional sources of demand for carbon removal are likely to come online in the next decade, stemming from compliance and voluntary markets (see Exhibit 4, next page), but **this potential future funding is unlikely to be sufficient to generate the portfolio of Gt-scale-ready solutions that will be needed by 2035**.

Over the next decade, compliance demand could come from emissions trading systems (or schemes, ETSs) or other compliance mechanisms at the national, subnational, or supranational level if supportive regulations are passed. For example, the United Kingdom is in the process of integrating carbon removal into its ETS, the European Union is considering integrating carbon removal into its ETS, and carbon removal is included in the Paris Agreement Crediting Mechanism, although it is not yet operational. Exhibit 4 lists several voluntary and compliance mechanisms that could increase demand for carbon removal in the future. However, projected prices in these markets may well be too low to incentivize purchasing of more expensive, higher durability carbon removal before 2035. Additional support will be needed to drive cost reductions in high-cost carbon removal approaches in the near term.

Voluntary demand from corporate sustainability efforts is expected to continue in the next decade. Existing commitments and trends in voluntary markets are expected to create approximately 30 to 50 Mtpa of total carbon removal demand in 2030, approximately 80% of which is expected to be in more mature, lower durability carbon removal approaches like afforestation, reforestation, and revegetation.[26]

This level of demand could increase or decrease depending on a number of factors, including voluntary programs like the Science Based Targets Initiative (SBTi). SBTi is in the process of updating its Corporate Net-Zero Standard and is consulting on requiring companies to purchase carbon removal before the point of net zero. Carbon removal requirements from organizations like SBTi could increase corporate purchasing not only for those with SBTi-validated targets but also more generally by providing clear signals about the amount, timing, and types of carbon removal that are needed.

Overall, despite the encouraging progress in policy and voluntary market trends, there is not sufficient demand at a high enough price on the horizon. Voluntary carbon market commitments need to grow, and policy is needed to close the gap between existing carbon markets and costs for early carbon removal solutions. More specifically, public funding for carbon removal demand will need to increase to billions of dollars per year by 2035 and hundreds of billions of dollars per year by 2050 globally to meet climate goals. This funding can come from a mix of policy levers (e.g., direct procurement, ETS integration, tax credits) and revenue sources (e.g., treasury spending, revenues from ETS, fees on polluters). It is critical to send a clear signal that overall support will reach this level so that private investors begin deploying capital today to spur innovation and drive down costs.

Exhibit 4 **Mechanisms that could increase demand for carbon removal**

Mechanism	Opportunity for carbon removal
Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)	Mature carbon removal approaches are eligible; emerging carbon removal approaches are pending approval.
European Union Emissions Trading System	Carbon removal potentially integrated as early as 2031.
Japan's Green Transformation Emissions Trading System	Carbon removal eligible, not required, for up to 5% of total emissions covered.
United Kingdom Emissions Trading Scheme	Carbon removal potentially eligible as early as 2029, and a complementary contracts-for-difference program is being developed.
California's Low Carbon Fuel Standard	DAC is eligible but is not required.
Voluntary carbon market	Emerging carbon removal approaches are integrated but make up a small fraction of total volume because of price differential.
Science Based Targets Initiative	Carbon removal may be allowed or required in guidance to be updated in 2026.

Note: This is a non-exhaustive list of mechanisms that could increase demand for carbon removal.

RMI Graphic. Source: RMI analysis

2.2 Other critical gaps

In addition to funding, there are **several other critical gaps to scaling carbon removal**. These gaps, which are interrelated, are described in Exhibit 5. Interventions to increase funding could also support the growth of the carbon removal industry by filling these gaps.

Exhibit 5 Critical gaps in scaling carbon removal

Gap	Description
Cost reduction	Carbon removal technologies are currently expensive, and economies of scale and learning through deployment need to occur for technologies to come down in cost.
Deployment	More deployment is necessary to prove, pilot, and refine a wide range of carbon removal technologies across geographically diverse areas.
Funding	Funding on the order of $20 billion per year by 2035 is needed to enable midcentury scaling requirements. This funding will likely need to come from a variety of actors, including governments, corporations, and philanthropic organizations.
Global development	Development of carbon removal is needed across the globe because of natural resource constraints; global development could also spur economic development, harmonize standards, coordinate actors, and catalyze global competition.
Innovation	More innovation is necessary to refine existing technologies and create new ones.
Measurement	Technologies for measurement and modeling need to be further researched and developed across geographically diverse areas and the full range of carbon removal approaches, especially for open system and early-stage carbon removal approaches.
Societal trust and knowledge	Knowledge of and trust in carbon removal needs to increase to generate the community and policy support needed for carbon removal to scale.
Standards and methodologies	Standards and methodologies need to be developed, agreed upon, and harmonized across borders to avoid a race to the bottom on quality and to ensure carbon removal deployment yields the desired results.
Shared infrastructure	Infrastructure that needs to be shared by multiple projects must be planned and developed for multiple removal and storage approaches.

RMI Graphic. Source: RMI analysis

Section 3: Why a Government-Led AMC

Section at a Glance

- **A global, government-led AMC** would offer a catalytic mechanism for **accelerating carbon removal** at its current stage of development and is well suited to **filling several critical gaps** the industry faces.
- Private investors and voluntary purchasers of carbon removal are increasingly waiting for governments to act, and **an AMC could attract billions of dollars in additional funding** and accelerate innovation across a range of solutions.

3.1 The right tool for right now

An AMC led by multiple governments would provide an ideal vehicle to catalyze carbon removal funding and deployment in the near term. In a government-led AMC, multiple governments would agree in advance to purchase (or similarly drive demand for) a certain amount of carbon removal (in tons or dollars) over a specified time frame, thereby establishing a more robust market for carbon removal. As noted earlier, AMCs have been used to support vaccines and carbon removal in the past, successfully leading to innovation and deployment in each of these fields.[27]

One core benefit of an AMC led by multiple governments is that governments would be centrally coordinated around priorities and a vision for carbon removal. Currently, governments, even ones making strides on carbon removal (see more in Exhibit 10, page 31), are operating individually. However, a government-led AMC would create a venue for multiple governments to align around standards, research and policy priorities, and the necessary steps to create a harmonized, global carbon removal market. Rather than loosely coordinated information sharing among governments interested in carbon removal, a government-led AMC would create avenues for structured, efficient coordination.

In addition to providing a venue for coordination, a government-led AMC for carbon removal would solve several problems preventing the industry from scaling. Critical gaps facing carbon removal are outlined in *Section 2.2*, and Exhibit 6 (see next page) describes the potential for an AMC to fill these gaps.

Exhibit 6 Potential for an AMC to fill critical gaps in scaling carbon removal

Gap	Filled by AMC?	Description
Cost reduction	**Yes**	An AMC can create economies of scale because purchases are large and limit redundancies across multiple purchasers. Deployment funded by an AMC also leads to cost reduction through learning.
Deployment	**Yes**	An AMC catalyzes deployment by creating a market for carbon removal and contracts with carbon removal suppliers.
Funding	**Yes**	An AMC guarantees a certain amount of money will be spent on carbon removal by a certain date; it also catalyzes additional private-sector investment.
Global development	**Maybe**	If an AMC is designed by several countries and allows cross-border funding, it could lead to global development.
Innovation	**Maybe**	If an AMC prioritizes funding diverse, early-stage approaches (as compared with commercialized, mature approaches), it could lead to more innovation in the space.
Measurement	**Maybe**	If an AMC prioritizes funding approaches facing measurement challenges, it could support the development of improved measurement.
Societal trust and knowledge	**Maybe**	If an AMC sets a high bar for community engagement and safety, it could increase trust in and knowledge of carbon removal.
Standards and methodologies	**Yes**	An AMC involving multiple governments would push actors to agree on standards, facilitating broader harmonization.
Shared infrastructure	**No**	It is unlikely an AMC alone would lead to the build-out of shared infrastructure, such as CO_2 transport and storage networks.

RMI Graphic. Source: RMI analysis

3.1.1 Gaps an AMC *will* fill

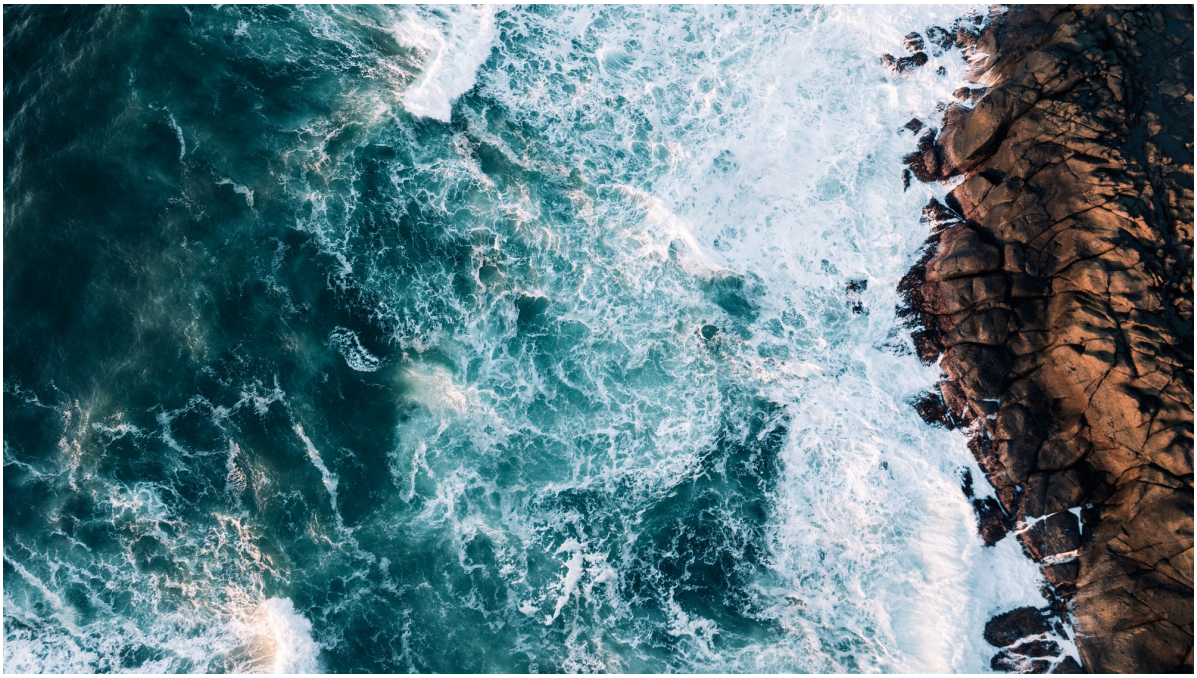
A government-led AMC would fill several critical gaps in scaling carbon removal, including increased funding, increased carbon removal deployment, cost reductions, and the development (and potentially harmonization) of standards and methodologies.

By definition, a government-led AMC guarantees a certain amount of government funding for carbon removal by a certain date, helping to close the carbon removal funding gap. When the public sector signals that it is committed to building the carbon removal market, investors and companies may view carbon removal investments and purchases as less risky, catalyzing additional private-sector activity. An AMC could also be designed to allow direct matching of initial government spending with corporate contributions, therefore increasing the impact of government spending (explored in *Section 4.3*). Finally, an AMC would also provide an effective platform for philanthropy to direct funding into carbon removal, as the Global Alliance for Vaccines and Immunization (Gavi) provided for the Gates Foundation.

This increased funding would catalyze increased deployment of carbon removal; when carbon removal suppliers have guaranteed buyers and funding, deployment is far more likely to occur. For example, Frontier Climate, a private-sector AMC for carbon removal, has gotten numerous projects off the ground, including over 1.5 million tons contracted and over 15,000 tons delivered.[28]

An AMC is likely to drive cost reductions in the carbon removal space in multiple ways. Large purchase volumes can create economies of scale by supporting larger project sizes and reducing diligence and transaction costs. A central procurement mechanism, if used, could also lower costs by eliminating redundant tasks and infrastructure across multiple governments. Learning by doing is also a key lever, and the increased deployment spurred by an AMC could help drive cost reductions.

Finally, an AMC could help drive alignment on standards for carbon removal. Negotiations on standards and quality would have to occur with multiple governments working together to form an AMC, giving governments an opportunity to set a high bar for carbon removal globally. If multiple governments agree on a high bar for carbon removal, voluntary and domestic markets may follow suit as well, driving the overall harmonization of standards.



3.1.2 Gaps an AMC *may* fill

Depending on how an AMC is designed, other critical gaps in scaling carbon removal may or may not be filled, including spurring global development, supporting innovation, improving measurement, and increasing societal trust in and knowledge of carbon removal.

To start, an AMC could be set up to cover a wide range of geographies (either when determining eligible buyers or suppliers) and facilitate cross-border funding, thus spurring the development of a global carbon

removal industry. Governments designing an AMC may be interested in cross-border operations to spur economic development, align global actors on standards and priorities, ensure that a diversity of carbon removal approaches can scale with responsible resource use, and enable international flows of capital. However, governments may also be motivated to build a domestic industry and restrict international operations. The way an AMC incorporates cross-border funding is central to whether global development is an outcome. These design trade-offs are further explored in *Section 4.2*.

Additionally, an AMC could lead to increased innovation and improved measurement if early-stage approaches are supported. Carbon removal approaches are still being invented, existing approaches vary in maturity, and the costs and accuracy of measurement vary widely. Stakeholders designing an AMC need to consider which approaches to include and the implications for how the AMC motivates different forms of innovation and measurement. Section 4.2 explores the design trade-offs of including a variety of carbon removal approaches with differing measurement readiness levels as eligible products in an AMC.

Finally, if an AMC sets a high bar for community engagement and safety in carbon removal project development and if it conducts outreach to the public, it could help build knowledge of and trust in carbon removal. RMI's AMC for Carbon Removal Design Decisions Hub explores the option of including capacity building and outreach as a central function of an AMC.

3.1.3 Gaps an AMC *is unlikely* to fill

While an AMC could fill most critical gaps carbon removal faces today, it is unlikely that an AMC alone could spur the creation of shared infrastructure for carbon removal, such as CO_2 pipeline/transportation networks or other infrastructure that requires multiple projects to sustain its creation. Although an AMC spurs project development, it is not suited to addressing collective action and planning issues typically resolved by governments through other means.

3.2 AMC is only one piece of a broader toolkit

An AMC is well suited to solving many of the challenges the carbon removal industry faces today. However, other mechanisms are needed to play complementary roles. For example, regional planning and supply-side incentives may be needed to establish shared infrastructure that is relevant for carbon removal project development, and research and development funding may be needed to discover entirely new concepts that will benefit from demand-pull support at a later stage.

A government-led AMC can lay the groundwork for mechanisms that require greater lead time to set up but are better and more scalable long-term solutions, like compliance systems that integrate carbon removal. Exhibit 7 illustrates which key gaps different mechanisms would be well suited to solving and illustrates that no single mechanism is guaranteed to fill all the critical gaps in scaling carbon removal; however, a government-led AMC has the potential to make progress on almost all of them in the near term. For additional information on the ratings in Exhibit 7, see *Appendix 5*. Next, *Section 4* dives into how AMC design options will have different impacts on the carbon removal industry.

Exhibit 7 Possible mechanisms and which gaps they fill

	Gov.-led AMC	Individual gov. compliance regimes	Individual gov. demand incentives	Individual gov. procure. programs	Private-sector AMCs	Private-sector pledges	R&D funding	Supply-side incentives	Indust. hubs/ clusters	Regional planning
Cost reduction	✓	✓	◆	◆	✓	◆	✓	◆	◆	X
Deployment	✓	✓	✓	✓	✓	◆	✓	✓	✓	◆
Funding	✓	✓	✓	✓	✓	◆	✓	✓	✓	◆
Global development	◆	◆	◆	◆	◆	◆	◆	X	X	X
Innovation	◆	◆	◆	◆	◆	◆	✓	◆	◆	◆
Measurement	◆	◆	◆	◆	◆	◆	◆	◆	X	X
Societal trust and knowledge	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Standards and methodologies	✓	◆	◆	◆	◆	◆	X	◆	X	X
Shared infrastructure	X	◆	X	X	X	X	X	✓	✓	✓

✓ **Well-suited** to achieving outcome

◆ **Possibly well-suited** to achieving outcome, depending on design of mechanism

X **Not well-suited** to achieving outcome

Note: For additional explanations of these ratings, see Appendix 4, which includes a more detailed exhibit for each mechanism listed in Exhibit 7.

RMI Graphic. Source: RMI analysis

Section 4: Designing an AMC

Section at a Glance

- This section provides an **overview of the process of designing an AMC,** including a discussion of the **important step of setting goals** as well as several **key design choices** related to AMC scope, creation, and operation.
- **RMI's AMC for Carbon Removal Design Decisions Hub** reviews AMC design choices in greater depth, including affiliated trade-offs for over 30 design elements and over 100 separate design options.[29]

4.1 Overview

Before stakeholders begin designing an AMC for carbon removal, it is critical to set goals to ensure alignment on desired outcomes. Potential goals for a government-led AMC for carbon removal include:

- Supporting a portfolio of carbon removal solutions to commercialization
- Aggregating demand to help projects reach final investment decision and secure financing
- Developing and harmonizing high-quality standards for carbon removal
- Reducing transaction costs for governments or other members
- Supporting economic development across diverse geographies
- Demonstrating high-quality carbon removal projects
- Deploying a certain amount of carbon removal by a certain date
- Initiating contracts across borders to facilitate a global market
- Aligning with other mechanisms, such as ETSs or other compliance programs
- Educating the public about the importance of carbon removal
- Building capacity for governments with limited experience with carbon removal
- Developing measurement technologies for early-stage carbon removal approaches
- Fostering competition among governments to lead on carbon removal
- Garnering as much membership as possible

Once goals have been set, governments need to make several important choices related to AMC design, navigating trade-offs across several design categories, summarized in Exhibit 8.

Exhibit 8 Important AMC design elements

Design category	Key topics for consideration
Market definition and product eligibility	Scope of the market covered and product eligibility criteria, including types of funding, carbon removal approaches, and geographies
Buyers and suppliers	Types of eligible buyers and suppliers
Standards and methodologies	Process by which standards and methodologies for carbon removal procurement and delivery are selected and created
Procurement facilitation	Procurement process, including which parties are responsible for sourcing, conducting diligence, and contracting
Registries	Use of a registry (or registries) to track carbon removal purchases
Project monitoring	Process by which ongoing monitoring of projects supplying carbon removal is conducted
Cross-border funding	Incorporation (or exclusion) of cross-border funding and associated implications
Legal structure	The way an AMC is legally incorporated and structured
Governance	The way an AMC is governed and decisions are made, including options for governing bodies (number, scope, participants)
Funding of operations	The way an AMC obtains funding to support its operations
Other considerations	Inclusion or exclusion of other functions, including innovative financing and capacity building

RMI Graphic. Source: RMI analysis

The agreed-upon goals serve as vital touchstones for resolving important design choices. The following section describes several key design decisions and how each influences the impact of an AMC on the carbon removal industry. For more detailed design options and implications for all categories mentioned in Exhibit 8, see RMI's *AMC for Carbon Removal Design Decisions* ***Hub***.

4.2 Key design decisions

Many design decisions must be made when planning and launching an AMC, but a few key decisions have outsized impact. This section explores four key design decisions, including which carbon removal approaches should be eligible, how standards and methodologies are chosen, how cross-border funding is (or is not) integrated, and how procurement occurs. Additional design considerations can be found in RMI's *AMC for Carbon Removal Design Decisions* ***Hub***.

4.2.1 Carbon removal approaches

Carbon removal encompasses a diverse range of approaches, and an AMC needs to determine which are eligible for procurement through the AMC. Eligibility could be limited to specific approaches or be based on performance characteristics of approaches (e.g., durability, risk of reversal, co-benefits), or eligibility criteria could vary among individual AMC members.

If an AMC supported only **specific approaches** (e.g., only DAC, only enhanced rock weathering (ERW)),[ii] this would channel funds toward specific approaches but would prevent supporting a portfolio of solutions. This could reduce the potential impact of the AMC and the success of the carbon removal industry in the long term. By providing a demand signal for only a few approaches, others are more likely to fail.

Carbon removal encompasses a diverse range of approaches, and an AMC needs to determine which are eligible for procurement through the AMC. Eligibility could be limited to specific approaches or be based on performance characteristics of approaches, or eligibility criteria could vary among individual AMC members.

Alternatively, an AMC could decide to support approaches based on performance or quality criteria. Take durability as an example; although this paper does not set an exact timescale for what constitutes low-durability or high-durability carbon removal, it encourages those designing an AMC to consider the trade-offs of including varied approaches based on the length of time they store removed CO_2. For example, **narrowing the scope to just low-durability carbon removal** may help scale more affordable approaches and result in more tons of removal in the near term. However, this approach would fail to support more nascent high-durability approaches, which are most in need of funding to advance deployment and move down the cost curve.

On the other hand, narrowing the scope of an AMC to **just high-durability carbon removal** is supportive of advancing the most nascent approaches that will be needed to achieve removal targets. However, excluding support of low-durability carbon removal may isolate countries that have high potential for deploying low-durability removals. This exclusion could also risk delaying short-term immediate removals.

An AMC that covers **both low- and high-durability carbon removal** risks raising the complexity of AMC operations, especially when operating registries, accounting for removals, and setting standards, because of complexities around definitions of durability and quality. However, this broadening would open the AMC to the greatest number of potential members and support the broadest portfolio of carbon removal approaches. Additionally, it would fill a gap in the ecosystem because no AMC currently covers both low- and high-durability carbon removal.

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ii **ERW is defined as** acceleration of the natural geologic weathering process through the spreading of finely ground alkaline materials on agricultural, urban, or forest soils, or on coastlines, where it reacts with CO_2 and water to produce dissolved inorganic carbon.

If low-durability and high-durability carbon removal are included in an AMC's scope, the design should consider how to account for the performance differences between the two categories if buyers are using the credits to make compensation claims. This might include mechanisms like a buffer pool, a permanence reserve or another form of horizontal stacking, maintenance requirements, and replacement requirements. Allowing the AMC to include the broadest range of approaches while maintaining a high standard of quality may attract higher participation and support more near-term delivery of credits.

Finally, eligibility could be determined at an AMC-wide level, or it could be **tailored to individual members**. Whether this design is possible depends on an AMC's procurement structure (discussed in *Section 4.2.4*), and an AMC should decide if eligibility can be tailored to member requests. If eligible approaches are tailored, the AMC risks not supporting a portfolio of solutions and funneling money into only a few popular approaches; however, this option to customize approaches could garner support from entities that are uncertain about joining an AMC.

4.2.2 Standards/methodologies

Standards are the high-level principles project developers must follow related to removal performance and claims, labor practices, environmental protection, safety, and other factors. An AMC needs to determine what standards it relies on.

The AMC could decide to **use existing standard(s) or create its own standard**. Although it is beneficial to learn from existing standards, adopting an existing one may prevent an AMC from having a standard aligned with its specific goals. However, creating a new standard requires more time and effort, especially given that several government entities need to agree on it. Creating a new standard could promote harmonization in the industry or could risk fragmentation if it conflicts with other mechanisms (e.g., ETSs, Paris Agreement Crediting Mechanism, EU Carbon Removals and Carbon Farming Regulation). Alternatively, an AMC could initially use existing standard(s) and later move to creating its own (e.g., if countries at first use their own standards but then move to the same harmonized standard after a certain period).

In addition to standards, the AMC needs to determine eligible methodologies. Methodologies are detailed procedures for quantifying removals that comply with an overarching standard. Methodologies vary depending on approach (e.g., a DAC methodology is different from an ERW methodology), which is not true of standards.

The AMC needs to either **use existing methodologies or create its own methodologies**. Methodology development is a technical process that would be a large undertaking for the AMC. Additionally, developing methodologies from scratch may be redundant. An AMC could allow entities to submit methodologies for approval, exerting control over the quality of methodologies without creating them from scratch. Alternatively, if an AMC adopts existing standards, it can simply accept methodologies that are compliant with the existing standard.

4.2.3 Cross-border funding

Treatment of cross-border funding in an AMC is a central design consideration, especially in the context of a global AMC with several government members.

In a scenario where **cross-border funding is prohibited**, there would be no possibility for pooled funding by governments and supply would be limited to member government geographies. While this scenario

may be less complex and avoid international rules around credit trading and government-specific rules about cross-border funding, it also reduces the flows of international capital and may limit the number of geographies able to participate.

In a scenario where **cross-border funding is allowed**, pooled funds would be an option and countries with significant deployment potential but limited resources for procurement could receive more inbound investment. However, there may need to be a second procurement mechanism that is geography-specific for governments with geographic funding restrictions. Although this would increase international flows of capital and provide governments flexibility, it would not stimulate the most cross-border funding.

As with the previous scenario, in a scenario in which **cross-border funding is encouraged/incentivized**, pooled funds would be an option, and members would be incentivized to invest in them. In this case, the AMC would need to determine which incentives should be used to increase investment in pooled funds (e.g., lower fees, matching commitments). Further, an additional non-pooled investment option would likely still be necessary.

In a scenario where **cross-border funding is required**, the AMC would need to ensure geographic diversity of suppliers and consider legal constraints on cross-border funding for all government participants. Although this option would support a global carbon removal market, it would likely reduce the number of countries involved and complicate AMC design.

An additional consideration for any scenario in which cross-border funding can occur is who gets credit for the carbon removal, including how emissions are accounted for, how they are transferred between governmental inventories, and how double counting is avoided. In some funding situations (such as direct governmental purchasing), these considerations could be relatively straightforward, and the country paying for carbon removal project would have full claim over the carbon removal. In other situations (such as philanthropic funding), there will be a bigger question about who has the right to claim the carbon removal, and in some cases (such as pay for practice), it may be difficult to quantify the carbon removal for emissions inventories.

4.2.4 Procurement

The procurement process of an AMC follows several steps from solicitation to conducting diligence to final decision-making to contracting. Each step of this process needs to be designed with the goals of the AMC in mind.

A solicitation occurs when an entity publishes information about a product or service it will procure and asks suppliers to bid to secure a contract. Members of an AMC could **either conduct solicitations themselves or have the AMC conduct solicitations on their behalf.** If members conduct solicitations, more time, money,

and internal expertise would be required to join the AMC. In this instance, members would have control over the process; however, they would still need to ensure solicitations are in line with AMC standards. If the AMC conducted solicitations on behalf of members, this would reduce work for members and could improve efficiency because a central entity would be conducting solicitations for several members versus each member running separate processes. However, centralized solicitations would increase the complexity of the AMC's operations.

The solicitation process could also vary by whether **members act as individuals, in groups, or all together**. If solicitations occur for individual members, the AMC could tailor solicitations to member restrictions (e.g., if a government entity is restricted by the types of projects it can fund). This might expand membership, but it would take the most time and effort for the AMC. Alternatively, solicitations could occur for groups of members with shared goals. Although group solicitations could save suppliers and the AMC time, it may be difficult to align several members on a single solicitation. Finally, solicitations could occur for all members together, which would provide suppliers with access to the largest number of potential buyers and vice versa. However, this is the least flexible option for members.

After solicitation, diligence needs to be conducted to ensure projects meet standards, are trustworthy, and will deliver what they claim. In an AMC, the **responsibility of diligence can fall on member countries, the AMC itself, or third-party service providers**. For members to conduct diligence, they would need access to relevant expertise and capacity, which would place a larger burden on members. The other option is for an AMC to conduct diligence on behalf of its members, which would require the AMC to resource adequate technical expertise or to outsource this function to a third party. In this instance, the AMC could construct a method or body to streamline this process and ensure it is standardized across solicitations.

The final decision about project selection could also reside with **either members or the AMC**. Retaining control over final procurement decisions may be a prerequisite for some countries' participation, and it may be difficult for an AMC to garner support from entities, especially government entities, if they do not have the final say in what projects supply their carbon removal. However, if members hold decision-making power, the AMC may be less able to distribute funds to a diversity of carbon removal approaches, geographies, etc.

Once carbon removal projects are selected, contracts must be completed, and **either members could sign contracts directly with project developers or the AMC could act as the procuring entity with mechanisms in place to resell carbon removal to members**. Members contracting directly with projects may reduce AMC operational complexity, as funds would flow directly from buyers to suppliers without the AMC as an intermediary. However, this design would create more burden for members, especially if members procure carbon removal across geographies and approaches. Alternatively, the AMC could contract with project developers and then resell carbon removal to individual members, small groups of members, or to a pool of all members. This system would increase operational complexity and risk for the AMC mechanism because it would be responsible for managing large funding flows.

Section 5: Taking Action

Section at a Glance

- **Governments** should **fund** carbon removal, work with others to **start** an AMC, and **integrate** carbon removal into long-term plans.
- In addition to potentially **mitigating the worst effects of climate change** through the scale-up of carbon removal, governments that start an AMC would **secure visibility** into the frontier of carbon removal technology development and **a leadership position** in the emerging carbon removal industry.
- **Governments are vital** to supporting the carbon removal industry, and several governments could build on their current carbon removal actions by participating in an AMC.
- **Companies, philanthropic organizations, nongovernmental organizations (NGOs), and academia** have distinct roles to play in supporting an AMC, too, and important reasons to support it.

5.1 Overview

This discussion paper has laid out the need for a government-led AMC to get the carbon removal industry Gt-scale-ready by 2035 and analyzed important AMC design considerations. This section describes how governments could catalyze the carbon removal industry by launching an AMC and how they would benefit. The section also describes how other stakeholders can play critical roles in an AMC.

5.2 Governments

Governments could derive a number of unique benefits from helping to launch an AMC. First, they would gain visibility into the frontier of carbon removal technology development and performance. By developing an AMC mechanism focused on supporting carbon removal innovation and deployment, involved governments would have the most up-to-date information on the future of the carbon removal field.

Second, by being first movers on carbon removal, countries can position themselves centrally in the design of the global carbon removal industry. In this position, countries could align global carbon removal standards with their existing policies, ensure a particular carbon removal pathway is included to position them well as a supplier because of abundant natural resources, position themselves as trading hubs, or pursue other interests.

Moreover, by leading a government AMC, a government could build its internal carbon removal capabilities and be well-prepared for multilateral negotiations where carbon removal is relevant. Participating in the AMC would allow a government to approach these debates with the best available information on carbon removal, increasing the chances of a favorable outcome.

Additionally, a government that participates in an AMC can strengthen its working relationships with other governments. Building out the carbon removal industry will require a global effort. Governments can build allies and be in a position of strength as the carbon removal industry develops and as combatting the climate crisis continues.

> **By participating in an AMC, governments can also spur economic development; provide environmental, health, and resiliency benefits; further climate justice; and demonstrate leadership in climate action.**

Furthermore, by launching an AMC and ensuring their place in developing the carbon removal industry, governments would have an additional tool to manage climate and security risk. Carbon removal can help a government protect against climate risk while also advancing its own economic and industrial potential.

By participating in an AMC, governments can also spur economic development; provide environmental, health, and resiliency benefits; further climate justice; and demonstrate leadership in climate action. For example, carbon removal can create economic growth by creating jobs, unlocking additional revenue streams for existing industries, and creating lucrative export markets.

The Rhodium Group estimates there will be between 95,000 and 130,000 jobs in project investment, operations, and management across many carbon removal approaches once the high-durability carbon removal industry is at a scale of 100 Mtpa.[30] Alkire and Phillips estimate that an additional 31.9 direct and indirect jobs are created for every $1 million invested in reforestation in the United States.[31]

Existing industries can also generate economic benefits from carbon removal — not just emerging companies dedicated to carbon removal. For example, mining operations can use tailings for certain carbon removal approaches, such as surficial mineralization,[iii] unlocking an additional revenue stream from process waste.[32] When integrated on a global scale, carbon removal holds the potential for economic development through the creation of domestic and international markets.

Further, when done well, carbon removal can have additional environmental, health, and resiliency co-benefits, depending on the carbon removal approach. One example of a possible co-benefit is biomass burial, a biogenic carbon removal approach that can help with vegetation management, reducing wildfire and power outage risks.[33] Exhibit 9 (next page) outlines additional examples of co-benefits for different carbon removal approaches.

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iii **Surficial mineralization** is defined as enhancing the natural capacity of excavated or processed alkaline feedstock to passively react with atmospheric CO_2 — through crushing, grinding, spreading, heating, or other physical or chemical means — to form carbonate minerals.

Exhibit 9 Example carbon removal co-benefits for select approaches

Taxonomy	Approach	Example co-benefit
Biogenic carbon removal	Biomass burial	Helps with vegetation management, reducing wildfire and power outage risks; wildfires cost the US between $394 billion and $893 billion each year in economic costs and damages.[34]
	Afforestation/ reforestation	Helps protect and restore natural ecosystems, can improve soil health; some estimates calculate that one hectare of restored tropical forests provides over $5,000 in services.[35]
Geochemical carbon removal	Surficial mineralization	Can reduce environmental and health hazards of mining wastes, such as asbestos; it is estimated that existing asbestos tailings in Canada and the US can be used to remove 750 million tons of CO_2 while preventing health risks.[36]
	Terrestrial enhanced weathering	Can improve soil health and reduce the need for fertilizer when applied to farmland; initial studies have found basalt amendments can increase agronomic performance of crops, including higher yield averages.[37]
Synthetic carbon removal	Electrochemical alkalinity production	Can help mitigate ocean acidification; one study found a global average annual loss of $47 to $58 per capita in 2100 due to ocean acidification.[38]
	Direct air capture	When paired with desalination processes, can reduce the salinity of brine discharged to the ocean, mitigating hazardous impacts on the environment.[39]

RMI Graphic. Source: RMI analysis and sources 34–39 in endnotes. See *Appendix 2 — Glossary* for definitions of biogenic, geochemical, and synthetic carbon removal.

Carbon removal can also play a role in supporting climate justice. Globally, carbon removal can be used as a tool to clean up atmospheric pollution, the responsibility for which does not fall on all countries equally. The international trade of carbon removal may also create opportunities for less-wealthy countries to become exporters of carbon removal to more wealthy jurisdictions.[40] Additionally, as a new industry, the carbon removal ecosystem has a chance to correct historical injustices by setting a high bar for community engagement practices, exploring and incentivizing community-centered project ownership models, and ensuring co-benefits are fairly distributed and that risks are mitigated.[41] On a local level, carbon removal can be used as a tool to provide communities with agency, especially those communities that have been left out of decision-making during previous infrastructure and industrial build-out.

By launching an AMC and supporting carbon removal, governments have the opportunity to lead globally on climate action. Governments are already beginning to formulate and establish carbon removal policy, and these countries may be interested in building upon these existing efforts and cementing their international leadership on carbon removal by participating in an AMC. Exhibit 10 (next page) provides examples of past, current, or likely government carbon removal procurement programs, demand-side policies, and supply-side policies. However, this list of policies and countries is not exhaustive, and countries do not need to have existing carbon removal programs in place to participate in an AMC.

Exhibit 10 Select government programs related to carbon removal, past, current, or likely

Government	Program	Category
Canada	Low-Carbon Fuel Procurement Program within the Greening Government Fund	Government direct procurement
Denmark	Negative Emissions Carbon Capture and Storage Fund	Government direct procurement
United States	Department of Energy Pilot Purchase Prize	Government direct procurement
California	Low Carbon Fuel Standard	Compliance regime
European Union	European Union Emissions Trading System	Compliance regime
United Kingdom	United Kingdom Emissions Trading Scheme	Compliance regime
Japan	Green Transformation Emissions Trading System	Compliance regime
Sweden	Bioenergy Carbon Capture and Storage (BECCS) reverse auction scheme	Supply-side policy
Australia	CSIRO's CarbonLock	Supply-side policy
United States	Regional Direct Air Capture Hubs Program	Supply-side policy
United States	Section 45Q Tax Credit	Supply-side policy
Canada	Canada's Carbon Capture, Utilization, and Storage (CCUS) investment tax credit (ITC)	Supply-side policy
European Union	Innovation Fund, funding calls for net-zero technologies	Supply-side policy
European Union	Horizon Europe, several subprograms	Supply-side policy
European Union	Program for the Environment and Climate Action	Supply-side policy
Denmark	Innovation Fund Denmark, green missions	Supply-side policy
Japan	Japan Climate Transition Bonds, carbon recycling/CCS	Supply-side policy
United Kingdom	UK Research and Innovation's CO_2RE Flexible Fund	Supply-side policy

RMI Graphic. Source: RMI analysis

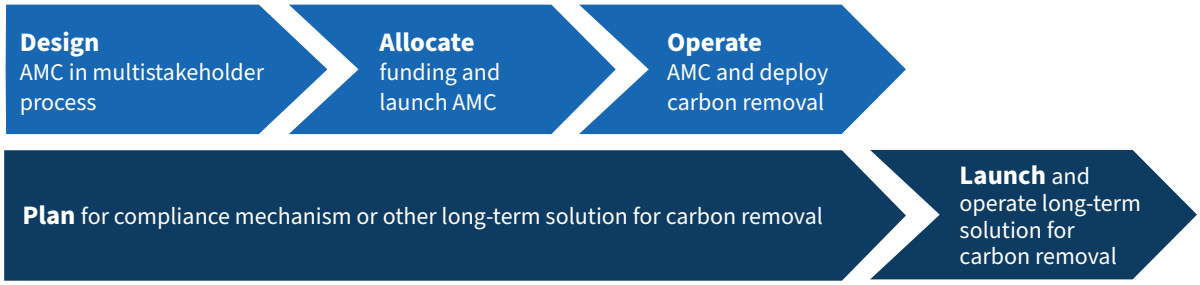
Governments that want to lead on carbon removal can take several critical near-term actions. First, governments should initiate a multistakeholder design and launch process for an AMC. The goals and characteristics of an AMC have significant flexibility, as detailed in Section 4. It is important for interested governments to engage in the design and launch process from the beginning to ensure that their interests, obligations, and constraints are reflected.

Second, governments should participate in the resulting AMC and allocate funding to the program. Governments could allocate entirely new funds, though this may require significant time to execute. They

may also have existing programs to support clean tech or carbon removal technologies that could be more readily directed to an AMC.

In tandem, governments should determine how carbon removal fits into their long-term climate goals and plans. They should advance the development of relevant policy mechanisms to enable carbon removal to fulfill its role in the long term. See Exhibit 11 for a visualization of this parallel process.

Exhibit 11 Two parallel tracks of government action to support carbon removal



RMI Graphic. Source: RMI analysis

See the benefits of these actions in Exhibit 12.

Exhibit 12 Government actions and benefits of an AMC

RMI Graphic. Source: RMI analysis

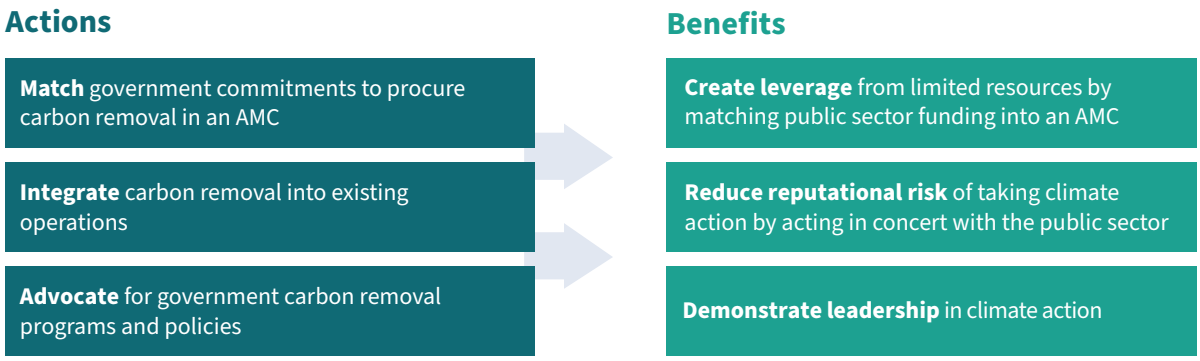
5.3 Corporations

Corporations have contributed to several AMCs, alongside or separate from governments, and depending on how a government-led AMC for carbon removal is designed, companies could play a similar role in it as previous AMCs.[42] Corporations could match government commitments, which not only increases the amount of carbon removal being purchased but could also incentivize governments to commit more funding. Under an AMC funded by several governments, corporate matching could be an even more powerful tool.

Whereas some companies could purchase carbon removal, others could integrate carbon removal into existing operations (e.g., wastewater, mining, and other industrial facilities with relevant waste streams) and become carbon removal suppliers.[43] Whether as buyers or suppliers, corporations could also go beyond purchasing to advocate for supportive policies for carbon removal in countries where they have influence.

Corporate purchasers could derive multiple benefits from these actions (see Exhibit 13). To start, by matching public-sector funding, they would be creating leverage from limited resources. Additionally, they could reduce the reputational risk of purchasing carbon removal by investing alongside public-sector entities. By purchasing from the same pool as governments and using the same standards, corporate action is likely to be seen as legitimate. Finally, contributing to an AMC is an opportunity for companies to demonstrate leadership in climate action.

Exhibit 13 **Corporate actions and benefits of an AMC**



RMI Graphic. Source: RMI analysis

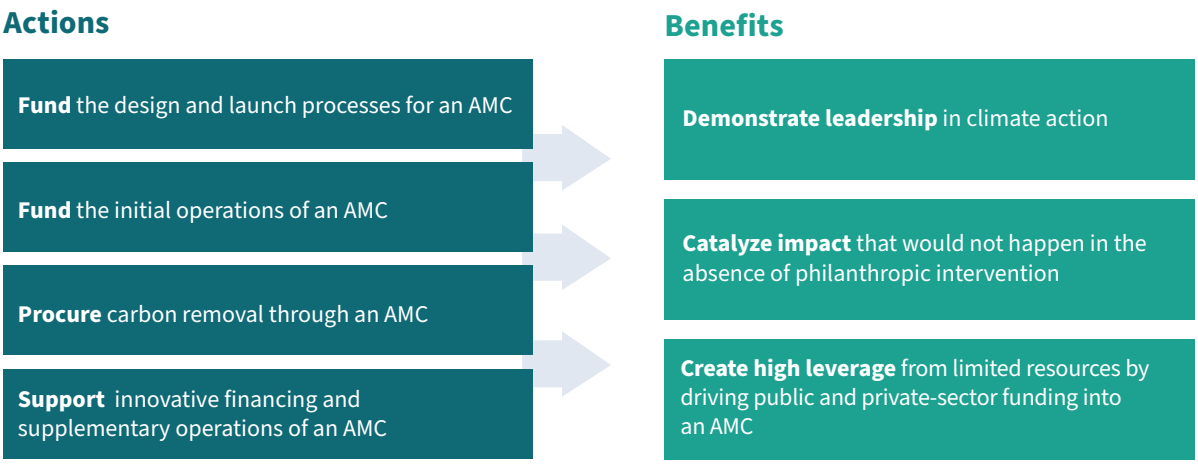
5.4 Philanthropy

Philanthropic organizations could play multiple critical and catalytic roles in an AMC, namely funding a collaborative design process and launch of an AMC and supporting its initial operations. To achieve long-term success, however, the AMC may need to become financially self-sustaining and transition away from relying on philanthropic support. Once an AMC is established, philanthropic organizations may also, depending on the design of the AMC, be able to provide matching funding for government or corporate commitments, using carbon removal to compensate for their own emissions.

Additionally, there may be opportunities for grant funding to support innovative financing mechanisms or other programs, such as outreach, education, and communication. Philanthropic organizations have played a large role in vaccine AMCs, unlocking financing for geographies that would not otherwise have been able to access them, and there may be opportunities for organizations to do the same for an AMC for carbon removal.[44]

Philanthropic organizations can benefit from providing this support by being seen as leaders in climate action and having a catalytic impact on a burgeoning industry. Organizations can also create high leverage from limited resources by enabling larger-scale government and corporate funds to funnel into the AMC (see Exhibit 14).

Exhibit 14 Philanthropic actions and benefits of an AMC



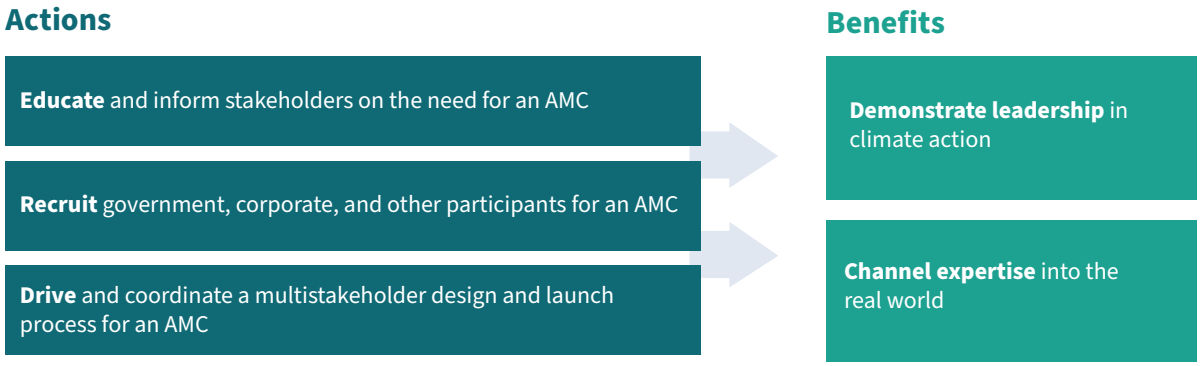
RMI Graphic. Source: RMI analysis

5.5 NGOs

NGOs focused on carbon removal, climate, or clean tech can play an important role in the design and implementation of an AMC. To start, they are well suited to educate and inform stakeholders on why an AMC is needed through outreach efforts. Through this outreach, NGOs can recruit and coordinate actors to help lead an AMC, especially governments. Finally, NGOs may be the best entities to create and launch a multistakeholder design process for an AMC because they can reduce the conflict-of-interest issues that might arise from governments or corporations launching and running the AMC.

NGOs can demonstrate leadership in climate action by kick-starting and supporting an AMC, while channeling their expertise into real-world impact. The carbon removal space is strongly supported by NGO roadmapping and research, and this expertise can be applied to real-world carbon removal procurement and scaling through an AMC (see Exhibit 15, next page).

Exhibit 15 NGO actions and benefits of an AMC



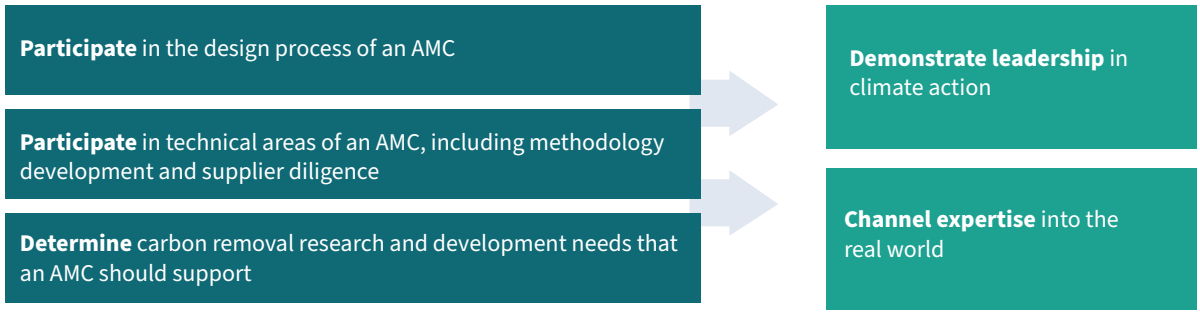
RMI Graphic. Source: RMI analysis

5.6 Academia

A government-led AMC would likely require experts to inform methodologies, standards, procurement, and ongoing updates to the mechanism. Academics and scientists from a variety of specialties, across economics, physical science, and social science fields, could play roles in determining the most effective design and implementation of an AMC. During the creation of the Pneumococcal AMC, several expert bodies were formed and consulted before the first rollout of vaccines occurred.[45] Frontier and other AMCs also consult technical advisers, and an AMC for carbon removal could benefit from experts in the field.[46] After an AMC effort is initiated, academics and scientists are vital to advising on technical areas like methodology development and supplier diligence. Additionally, ongoing academic research can highlight research and development needs in the carbon removal field that an AMC could support.

Like NGOs, academics can not only demonstrate leadership in the climate space, but they also have the opportunity to translate expertise into real-world impact, especially by informing AMC design and operations using evolving research findings and technical expertise (see Exhibit 16).

Exhibit 16 Academia actions and benefits of an AMC



RMI Graphic. Source: RMI analysis

Conclusion

Governments have a critical role to play in establishing demand signals for high quality carbon removal to ensure the industry can reach the scale needed to meet climate targets and also provide benefits to a variety of stakeholders. An AMC is a promising tool for stimulating coordinated, multilateral demand. This discussion paper explores the rationale for a government-led AMC and offers a menu of options to inform design and implementation of an AMC.

The work does not stop here. Interested members of government, civil society, and academia will be vital to the design and implementation process for a government-led AMC for carbon removal. A successful effort will also engage philanthropic organizations and companies to financially support the establishment of an AMC and to potentially participate as buyers alongside governments. The carbon removal ecosystem can learn from the successes of previous AMCs and create a mechanism that will not only bridge the carbon removal funding gap but also several other critical gaps facing the industry, enshrining carbon removal as the climate solution it needs to be.

Appendix 1: Abbreviations

AMC — advance market commitment

BECCS — bioenergy with carbon capture and storage

CO_2 — carbon dioxide

DAC — direct air capture

ERW — enhanced rock weathering

EU — European Union

GHG — greenhouse gas

Gt — gigaton

Gtpa — gigatons per annum

MRV — monitoring, reporting, verification

Mt — megaton

Mtpa — megatons per annum

NGO — nongovernmental organization

R&D — research and development

Appendix 2: Glossary

Advance market commitment — a financial mechanism designed to stimulate the development and deployment of new technologies by guaranteeing a future market for them.

Carbon removal — anthropogenic activities that remove CO_2 from the atmosphere and durably store it in geologic, terrestrial, or ocean reservoirs, or in products.[47] Carbon removal can be further categorized. Synthetic carbon removal includes approaches that use engineered systems powered by low carbon energy. Geochemical carbon removal includes approaches that use naturally occurring neutralization reactions between acidic forms of carbon and alkaline minerals. Biogenic carbon removal includes any approach that uses naturally occurring, biogenic carbon fixation to capture CO_2 from the atmosphere.[48]

Funding — umbrella term for financial support given to individuals, academia, companies, or others, including for: research, development, deployment of a technology or method, delivery of a product, and tax and other incentives.

Gigaton (Gt) — 1 billion metric tons.

High-durability carbon removal — carbon removal that stores CO_2 from the atmosphere on longer timescales. Durability can be determined by the inherent qualities of a storage method or by the risk of reversal (risk of CO_2 being re-released into the atmosphere).

Low-durability carbon removal — carbon removal that stores CO_2 from the atmosphere on shorter timescales. Durability can be determined by the inherent qualities of a storage method or by the risk of reversal (risk of CO_2 being re-released into the atmosphere).

Megaton (Mt) — 1 million metric tons.

Methodologies — procedures that must be followed by project developers and third parties to ensure that correct quantification of a project is occurring.[49]

Nature-based solutions — a type of low-durability carbon removal that relies on photosynthetic processes to convert and store CO_2 from the atmosphere into biomass. Nature-based solutions improve the capacity of a land sink to store CO_2, for instance through reforestation, afforestation, and land management.

Pooled fund — a fund that is contributed to by several different funders and is managed by a dedicated team or organization in an effort to increase the impact of funding.

Standards — high-level principles that outline how a carbon-removal project should be implemented and operated.[50]

Appendix 3: Carbon Removal Scaling Pathways

Exhibit A1 2035-2050 carbon removal portfolio scaling pathways

2050 deployment target (Gtpa)	Annual growth rate, 2035-2050 (%)	2035 deployment needed to reach 2050 target (Mtpa)
10	39	**70**
10	17	**950**
1	39	**7**
1	17	**95**

RMI Graphic. Source: RMI analysis

The amount of carbon removal deployment needed in 2050 will depend on climate action in the next few decades, but there is scientific consensus that it will be on the order of Gtpa.[51] Assuming a range of 1 to 10 Gtpa of carbon removal deployment in 2050 and a set of annual growth rates for carbon removal deployment, the necessary scale of deployment in 2035 can be estimated. In this analysis, the annual growth rates of 17% and 39% were modeled after the extremely fast industry growth of wind and solar from 2008 to 2023, respectively.[52] It is likely that carbon removal will grow at a much slower pace than solar and wind, so a higher level of deployment in 2035 will likely be needed than is listed in Exhibit A1. These estimates, especially those that achieve 1 Gtpa in 2050, are therefore likely underestimates of the scale that will be needed. Regardless, the carbon removal industry is not on track to achieve this level of deployment across a diverse portfolio of solutions in the next 10 years and needs additional sources of demand to support its scaling as a whole.

Additionally, the carbon removal industry needs scaling across a portfolio of approaches to reach deployment levels in 2050.[53] Across all carbon removal approaches, scaling to billions of tons annually faces major constraints, including competition for land, biomass, and clean energy, as well as permitting, infrastructure, and workforce bottlenecks. Because of this, multiple approaches will likely be needed to reach the 1 Gtpa scale in 2050, which in turn means that multiple approaches must reach the 10 Mtpa scale by 2035. Some approaches, such as afforestation, may already be deployed at the ~10 Mtpa scale. However, to ensure a diverse set of scalable solutions by 2035, innovation should be boosted and support for multiple emerging approaches with less than ~10 Mtpa currently deployed should be increased.

Appendix 4: Exhibit 7 Assumptions and Rationale

Appendix 4 expands on the ratings found in Exhibit 7.

Ratings key

Well-suited to achieving outcome

Possibly well-suited to achieving outcome, depending on design of mechanism

Not well-suited to achieving outcome

Exhibit A2 The potential for individual government compliance regimes to fill critical gaps in scaling carbon removal

For an example of compliance regimes, see: Japan's GX-ETS

Gap and rating	Explanation
Cost reduction	Individual government compliance regimes are likely to cause cost learnings and drive down the cost of carbon removal because they create a large source of demand and lead to deployment and innovation.
Deployment	Individual government compliance regimes will lead to deployment because they create a source of demand (through direct procurement, mandated procurement, etc.) that will fund project development.
Funding	Individual government compliance regimes will lead to funding because they create a source of demand and therefore funding for carbon removal.
Global development	Global development could occur if an individual government compliance regime allows projects from other jurisdictions.
Innovation	Depending on what types of carbon removal are allowed in the compliance regime, innovation may be more or less likely to occur.
Measurement	Depending on what types of carbon removal are allowed in the compliance regime, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on if the government enacting the regime is trusted by the public and on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Standards and methodologies from other mechanisms could be adopted which, could lead to harmonization but may not occur.
Shared infrastructure	A government compliance regime could create shared infrastructure in the long term if it creates enough demand for several projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A3 The potential for individual government demand incentives to fill critical gaps in scaling carbon removal

For an example of demand incentives, see: US Department of Energy's Voluntary Carbon Dioxide Removal Purchasing Challenge

Gap and rating	Explanation
Cost reduction	Depending on amount of demand created, individual government demand incentives might lead to cost learnings and reductions.
Deployment	Individual government demand incentives will lead to deployment because they create a source of demand, even if small, that will fund project development.
Funding	Individual government demand incentives will lead to funding because they create a source of demand and therefore funding for carbon removal.
Global development	Global development could occur if an individual government demand incentive allows demand support from other jurisdictions.
Innovation	Depending on what types of carbon removal are incentivized, innovation may be more or less likely to occur.
Measurement	Depending on what types of carbon removal are incentivized, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Standards and methodologies from other mechanisms could be adopted, which could lead to harmonization but may not occur.
Shared infrastructure	It is unlikely that a demand incentive would create enough demand to spur enough projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A4 The potential for individual government procurement programs to fill critical gaps in scaling carbon removal

For an example of procurement programs, see: Canada's Low Carbon Fuel Procurement Program

Gap and rating	Explanation
Cost reduction	Depending on the amount of carbon removal procured, individual government procurement programs might lead to cost learnings and reductions.
Deployment	Individual government procurement programs will lead to deployment because they create a source of demand, even if small, that will fund project development.
Funding	Individual government procurement programs will lead to funding because they establish a certain amount of money to buy carbon removal.
Global dev.	If procurement programs allow for projects from other jurisdictions, then global development could occur.
Innovation	Depending on what types of carbon removal are procured, innovation may be more or less likely to occur.
Measurement	Depending on what types of carbon removal are procured, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Standards and methodologies from other mechanisms could be adopted, which could lead to harmonization but may not occur.
Shared infrastructure	It is unlikely that a procurement program would spur enough projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A5 The potential for private-sector AMCs to fill critical gaps in scaling carbon removal

For an example of private-sector AMCs, see: Frontier Climate

Gap and rating	Explanation
Cost reduction	An AMC can create economies of scale because purchases are large and limit redundancies across multiple purchasers. Deployment funded by an AMC will also lead to cost reduction through learning.
Deployment	An AMC catalyzes deployment by creating a market for carbon removal and contracts with carbon removal suppliers.
Funding	An AMC guarantees a certain amount of money will be spent on carbon removal by a certain date.
Global dev.	If a private-sector AMC allows for projects from other jurisdictions, then global development could occur.
Innovation	Depending on what types of carbon removal are supported, innovation may be more or less likely to occur.
Measurement	Depending on what types of carbon removal are supported, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on if private-sector entities are trusted by the public and the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Standards and methodologies from other mechanisms could be adopted, which could lead to harmonization but may not occur.
Shared infrastructure	It is unlikely that an AMC would spur enough projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A6 The potential for private-sector pledges to fill critical gaps in scaling carbon removal

For an example of private-sector pledges, see: First Movers Coalition

Gap and rating	Explanation
Cost reduction	Private-sector pledges are usually nonbinding and voluntary; they do not always lead to actual purchases, especially in the near term, and may not drive down costs.
Deployment	Private-sector pledges are usually nonbinding and voluntary; they do not always lead to actual purchases, especially in the near term, and may not lead to deployment.
Funding	Private-sector pledges are usually nonbinding and voluntary; they do not always lead to immediate contracts.
Global dev.	If a private-sector pledge allows for projects from other jurisdictions, then global development could occur.
Innovation	Depending on what types of carbon removal are supported, innovation may be more or less likely to occur.
Measurement	Depending on what types of carbon removal are supported, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on if private-sector entities are trusted by the public and the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Standards and methodologies from other mechanisms could be adopted, which could lead to harmonization but may not occur.
Shared infrastructure	It is unlikely that a pledge would spur enough projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A7 The potential for R&D funding to fill critical gaps in scaling carbon removal

For an example of R&D funding, see: Mission Innovation's Carbon Dioxide Removal Mission

Gap and rating	Explanation
Cost reduction	R&D funding is likely to lead to innovation and breakthroughs that reduce technology cost.
Deployment	R&D funding is likely to lead to pilot or demonstration projects.
Funding	R&D funding is inherently related to providing funding to carbon removal developers.
Global development	Coordinated R&D could lead to global development of carbon removal but only through a program that spans several geographies.
Innovation	R&D funding is focused on spurring innovation.
Measurement	Depending on the goals of the funding and the types of carbon removal supported, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	R&D funding is unlikely to lead to standard development and is especially unlikely to cause harmonization of standards across jurisdictions.
Shared infrastructure	It is unlikely that R&D funding would spur enough projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A8 The potential for supply-side incentives to fill critical gaps in scaling carbon removal

For an example of supply-side incentives, see: US 45Q tax credits

Gap and rating	Explanation
Cost reduction	Supply-side incentives may lead to cost reductions, depending on size of the incentive, how successful it is at catalyzing deployment, and whether innovation occurs through these deployments.
Deployment	Supply-side incentives are likely to lead to deployment because financial incentive is provided to supply (and therefore deploy) carbon removal.
Funding	Supply-side incentives provide a form of funding for carbon removal suppliers to build projects.
Global dev.	It is unlikely that governments would allow projects from other jurisdictions to be eligible for the incentive.
Innovation	Depending on what types of carbon removal are incentivized, innovation may be more or less likely to occur.
Measurement	Depending on what types of carbon removal are incentivized, improved measurement technologies may or may not be developed.
Societal trust and knowledge	Building societal trust and knowledge will depend on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Standards and methodologies from other mechanisms could be adopted, which could lead to harmonization but may not occur.
Shared infrastructure	Supply-side incentives would likely spur enough projects to justify and sustain the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A9 The potential for industrial hubs to fill critical gaps in scaling carbon removal

For an example of industrial hubs, see: US DOE's DAC Hubs program

Gap and rating	Explanation
Cost reduction	Industrial hubs may lead to cost reductions, depending on funding amount and whether innovation is a central feature of the hub.
Deployment	Industrial hubs are likely to lead to deployment in a specific region where funding is dedicated.
Funding	Industrial hubs offer funding for research, innovation, and/or deployment in a specific region.
Global development	Industrial hubs are focused on individual regions and are unlikely to connect global actors or catalyze global competition on carbon removal.
Innovation	Depending on what types of carbon removal are funded, innovation may be more or less likely to occur.
Measurement	It is unlikely that a carbon removal approach with early-stage measurement technologies would be supported at a large, commercial scale.
Societal trust and knowledge	Building societal trust and knowledge will depend on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Industrial hubs are focused on individual regions and are unlikely to cause harmonization of standards across jurisdictions.
Shared infrastructure	Industrial hubs would likely be focused on spurring not only projects within a region but also the creation of shared infrastructure.

RMI Graphic. Source: RMI analysis

Exhibit A10 The potential for regional planning to fill critical gaps in scaling carbon removal

For an example of regional planning, see: Texas Competitive Renewable Energy Zones

Gap and rating	Explanation
Cost reduction	Regional planning is unlikely to lead to cost reduction because it is unlikely that cost learnings would be a priority or that economies of scale would be achieved.
Deployment	Regional planning may lead to deployment if funding or a mandate is tied to it.
Funding	Regional planning may have funding tied to it.
Global development	Regional planning is focused on an individual region and does not have the goal of creating global development or competition on carbon removal.
Innovation	Regional planning may catalyze innovation, depending on what carbon removal approaches are supported and if they integrate with existing industry in novel ways.
Measurement	It is unlikely that regional planning alone could lead to the development of measurement technologies, given focus on deployment rather than early-stage innovation.
Societal trust and knowledge	Building societal trust and knowledge will depend on the bar set for ensuring safety and conducting community engagement.
Standards and methodologies	Regional planning is focused on an individual region and is unlikely to cause harmonization of standards across jurisdictions.
Shared infrastructure	Regional planning would likely aim to create and support shared infrastructure in a strategic way.

RMI Graphic. Source: RMI analysis

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