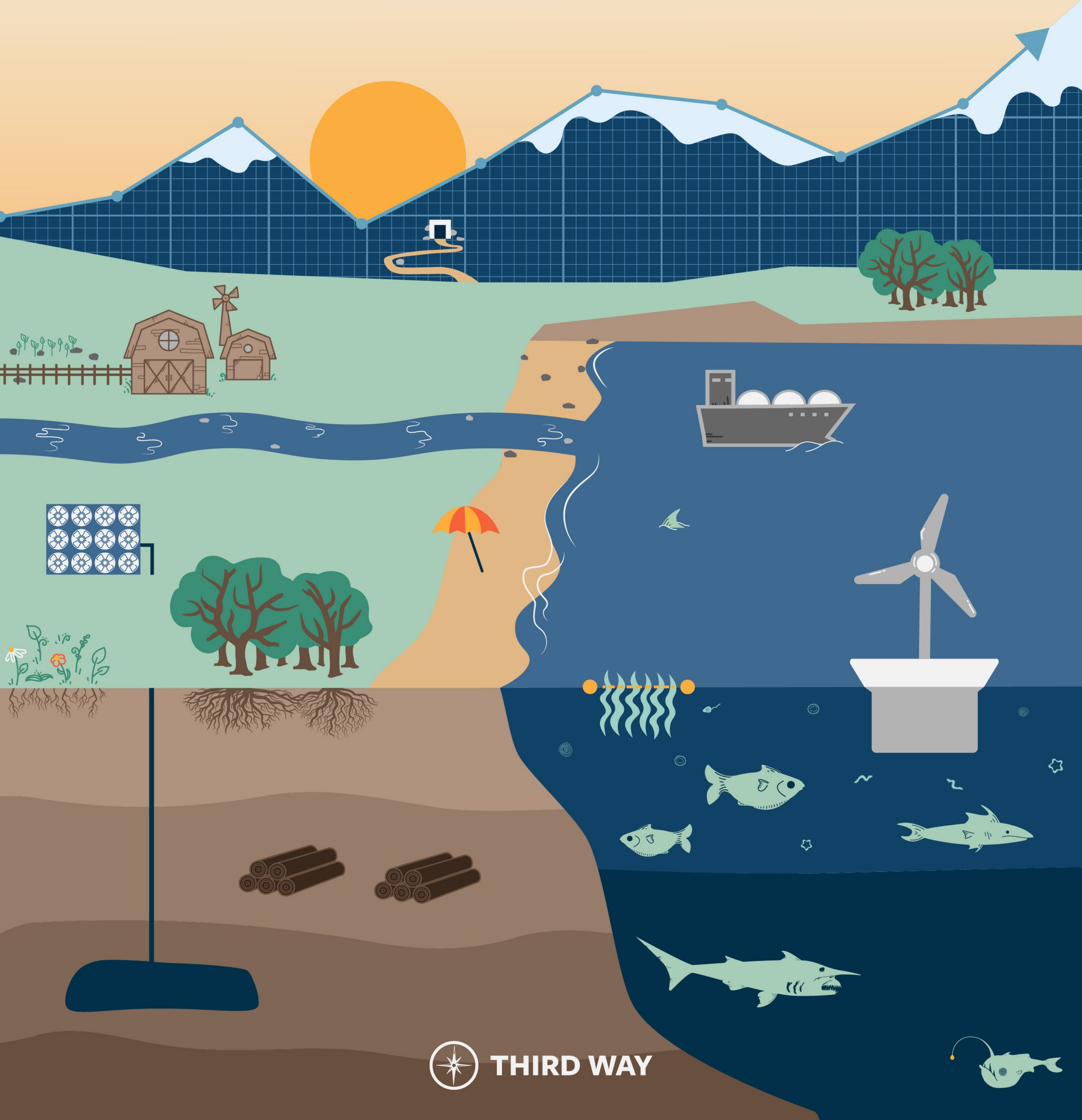
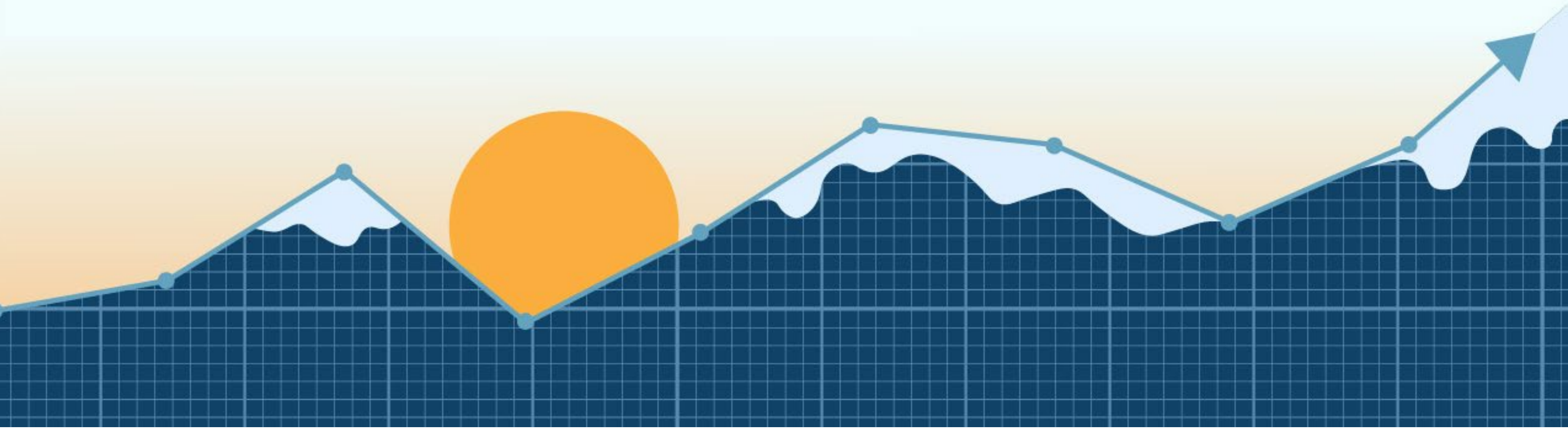
Scaling to the Skies

Policy Design Options for a New CDR Tax Credit



THIRD WAY



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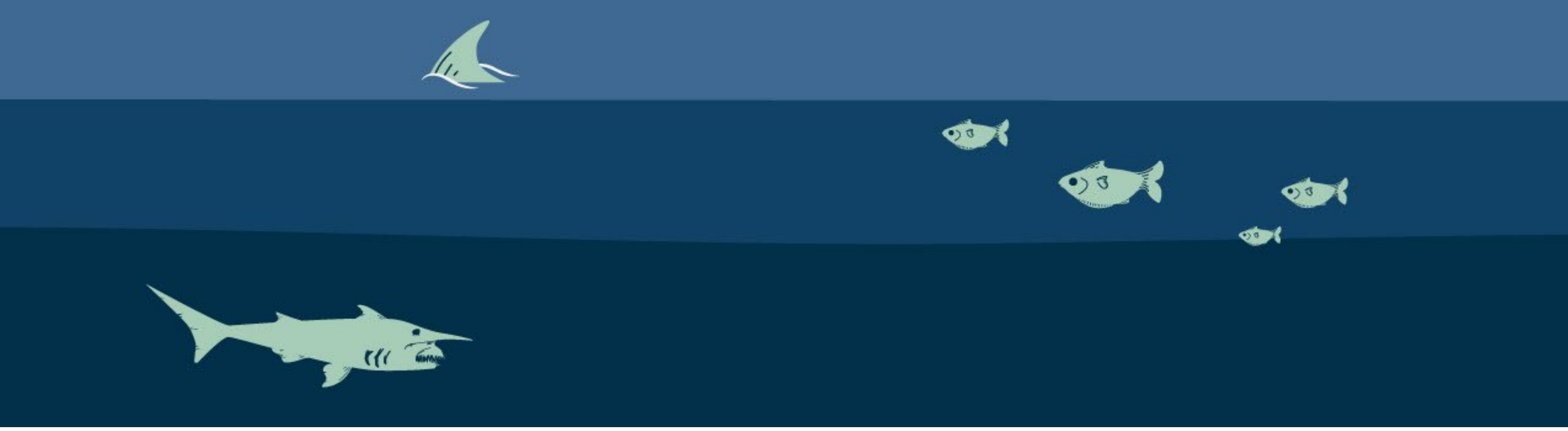

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THIRD WAY

Scaling to the Skies: A New Carbon Dioxide Removal Tax Credit

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Executive Summary

It is likely that within the next 5 years the world will reach 1.5 degrees of warming, exceeding the target cap on warming agreed to in the Paris Climate Accords. The effects of exceeding this target are dire and cannot be understated, but it is notable that the Intergovernmental Panel on Climate Change (IPCC) envisions scenarios where it is possible to return to a level of warming below 1.5 degrees and avoid breaching the 2.0-degree threshold. Those scenarios are achieved by rapidly pursuing decarbonization while simultaneously deploying Carbon Dioxide Removal (CDR). It is projected that to achieve that level of deployment the world will need to increase traditional land-based CDR methods by two-fold and nascent, generally technologically-based, CDR methods by 1,300 – 4,900-fold.

This task will not be small. It is also further complicated by the underlying economics of CDR methods. CDR is primarily a public good, even if it does have the potential to yield some marketable byproducts. That means that there is not an inherent existing market for the removal components of CDR methods. To successfully scale CDR, drive down the price of the methods that create removal, and build long-term markets for CDR it is necessary to enact robust policies that support CDR.

Currently, the United States supports a limited quantity of CDR methods through the existing 45Q tax credit. However, it is expected that it will not be possible to achieve the requisite level of removal needed by using these methods alone. Thankfully, there are multiple existing CDR methodologies beyond those supported by 45Q and as the field rapidly grows it is plausible that new ones will be created in the future.

This paper proposes that a new method-neutral CDR tax credit can help these methods deploy at the pace and volumes needed. The first section of this paper provides background on the characteristics that differentiate CDR methods and the current CDR policy landscape.

The second section describes in-depth options for how to design a new tech-neutral CDR tax credit. The primary considerations that are explored in that section are:

1. How to determine which methods should be eligible for the tax credit and how to factor permanence, measurement certainty, and environmental impacts into that determination.

2. How to determine if the tax credit should be structured as an Investment Tax Credit (ITC) or Production Tax Credit (PTC).

3. How to determine the credit value for a CDR tax credit, how to adjust that credit value to incentivize desirable behaviors, and how to approach the possibility of CDR methods being eligible for multiple tax credits.

4. How to determine what accountability measures – such as MRV requirements, LCA requirements, reporting requirements and auditing procedures – should be included in a tax credit and how to structure each of those measures.

The second section of the paper is broken down into four subsections that delve into various sub-options and choices that go into each of the above considerations. These options show the range of ways that a new CDR tax credit could be designed and describe the tradeoffs between different choices. The tradeoffs described are generally policy implications or legal barriers that may be encountered. Each of the four sections begins with a visual decision diagram that illustrates the various options within the topic considered in that section. This paper is intended to be used as a policy-agnostic reference on how to design a CDR tax credit.

PART ONE: Background

I. Introduction

Countering the effects of climate change will necessitate developing and scaling new carbon dioxide removal (CDR) methods.[2] CDR refers generally to any practice or technology that removes carbon dioxide from the ambient air or oceans.[3] CDR differs from traditional carbon management approaches such as carbon capture. Carbon capture activities capture emissions from a particular point source; CDR activities create "net negative" emissions by decreasing or "drawing down" overall carbon dioxide levels in the atmosphere. The IPCC identifies three objectives for CDR in its climate models: accelerating near-term emissions reductions; compensating for emissions from hard-to-decarbonize sectors; and reaching net-negative emissions eventually to stabilize and remediate the climate.[4]

The IPCC's most recent synthesis report found that there is a high likelihood that the planet will exceed 1.5 degrees of warming in the near term and well before 2050, which is the year most nations have pledged to achieve net zero emissions. The effects of reaching this warming milestone are dire. The IPCC notes the high likelihood that irreversible changes and damage to planetary systems and life on earth are likely to occur with each incremental increase in warming. Furthermore, the IPCC found that as warming increases known adaptation techniques will become less effective.

However, the IPCC notes that it is possible for the planet to overshoot 1.5 degrees of warming and then return to a lower level of warming within the century. This is possible in scenarios in which countries simultaneously engage in deep rapid decarbonization to reduce emissions going to the atmosphere and deploy CDR to remove carbon dioxide already in the atmosphere.

The IPCC synthesis report estimates that for every 10th of a degree that the planet overshoots 1.5 degrees a net total of 160-370 gigatons of carbon dioxide will need to be removed from the atmosphere by 2100 in order to return to 1.5 degrees. For context, in 2022 – when global carbon dioxide emissions reached an all-time high – 36.8 gigatons of carbon dioxide were emitted. Accordingly, the planet may need to remove nearly 10 times current annual global emissions by 2100 in order to return to 1.5 degrees of warming.[5]

A separate analysis by the Rhodium Group has found that the United States alone will need to remove 1-2 gigatons a year by mid-century in order to reach a net-zero target by that time.[6] Notably, a recent report on the state of carbon dioxide released by a coalition of international researchers has found that models for staying under 1.5 or 2.0 degrees of warming contemplate anywhere from a 1,300 – 4,900 fold increase in new CDR methods and a two-fold increase in terrestrial nature-based CDR.[7]

The purpose of this paper is to explore potential designs for a new U.S. federal CDR tax incentive. In addition to maximizing removals over time, a new tax incentive could help promote higher quality measurement, reporting, and verification (MRV); set and enforce standards around permanence; and breakdown barriers that the CDR sector shares with many emerging industries (e.g., access to capital and professional capacity).

II. Characteristics of CDR Methods

Numerous and very different CDR methods have emerged in the past few years. They have significant variation in permanence of removal, system type, measurability, technological readiness, cost, and non-removal impacts. The below chart breaks down these methods into different categories and lists methods within those categories. Many of these methods have multiple variations. The chart below excludes such sub-variants. Throughout this paper, the term project is used to refer to a specific CDR facility or operation that is an application of a CDR method or one of its sub-variants.

Table 1: Carbon Dioxide Removal Methods

Biomass with Carbon Removal and Storage (BiCRS)	Direct Capture	Alkalinity Enhancement	Carbon Sinking	Nutrient Alternation	Nature-based Methods
Bioenergy with Carbon Capture and Storage	Direct Air Capture	Terrestrial Enhanced Weathering	Seaweed Sinking	Artificial Upwelling	Afforestation/ Reforestation
Bio-oil Injection	Direct Ocean Capture	Coastal Enhanced Weathering	Artificial Downwelling	Ocean Fertilization	Forest Management
Biochar		Ocean-based Enhanced Weathering			Soil Management
Hydrogen Production from Biomass with CCS		Electrochemical Alkalinity Enhancement			Coastal Blue Carbon
Biomass Burial					Seaweed Cultivation

Note: Carbon Dioxide Methods are broken down by the removal mechanism in pictured table.

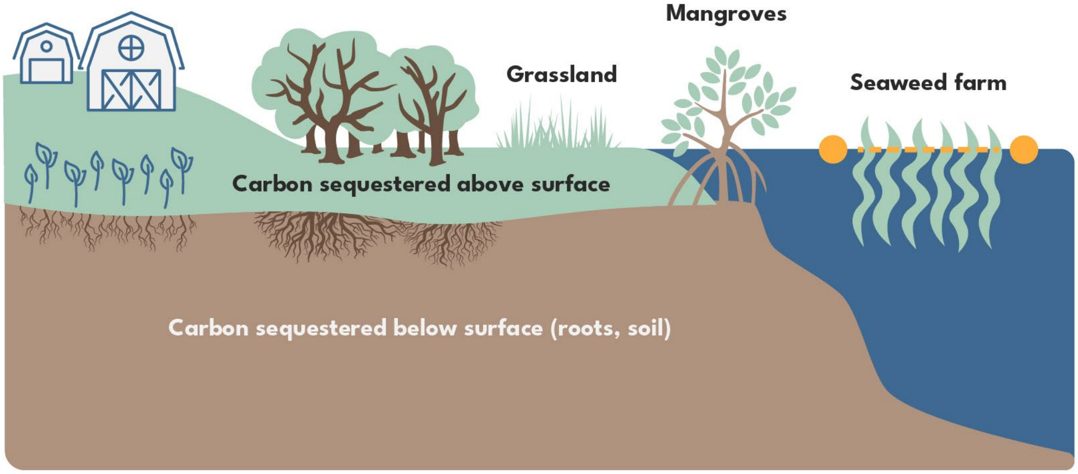
See Also: A Guide to Carbon Dioxide Removal Methods for in-depth explanations of listed methods and sources with information on each.

A. Low Permanence and High Permanence Removal

One way of categorizing CDR methods is by how long they can ensure removal of carbon dioxide from the atmosphere, referred to as "permanence." Low permanence methods remove carbon dioxide in the short term. High permanence methods remove carbon dioxide for the long term.

Low-permanence CDR methods rarely sequester carbon dioxide for more than 100 years and are subject to high "reversal" risks. Most often, this form of short-term sequestration occurs in plant matter, which is sometimes referred to as "nature-based" CDR. Examples of nature-based CDR methods include reforestation/afforestation, forest management, agricultural soil management, coastal blue carbon, and sea algae cultivation. Carbon dioxide naturally persists in the atmosphere longer than the storage duration of most nature-based solutions.[8] This limits the ability of nature-based solutions to provide long-term cumulative drawdown. However, nature-based methods do sequester a large quantity of carbon dioxide at any moment in time, preventing its release into the atmosphere, playing an important role in balancing the day-to-day global carbon budget, and limiting global warming.[9]

Figure 1: Nature Based Removal



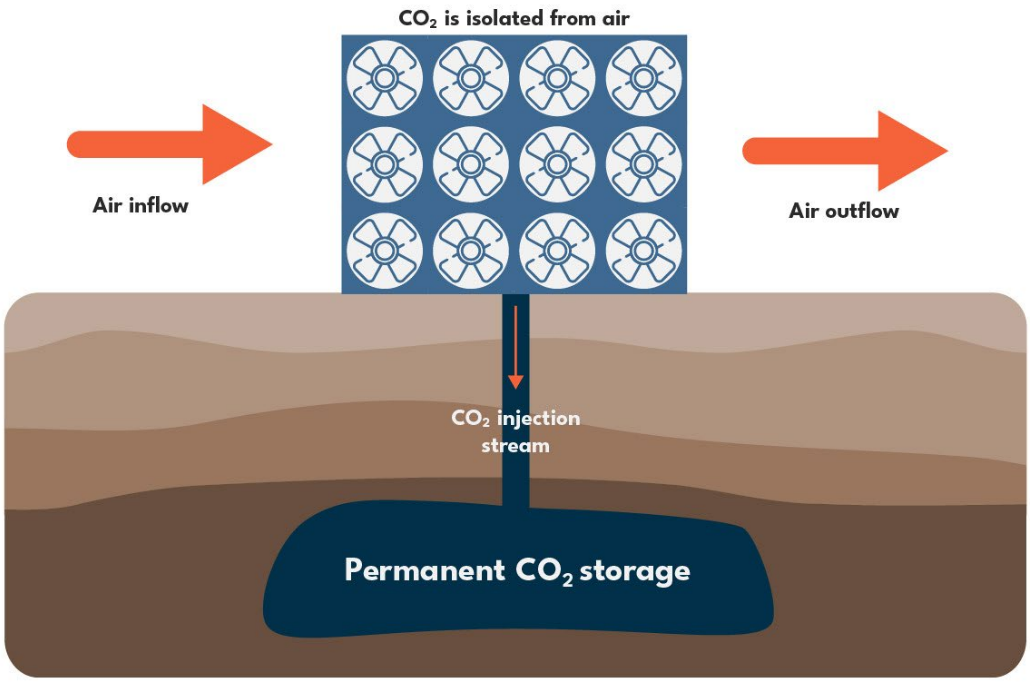
Note: Depiction of several nature-based removal methods taking place in the same landscape. Depicted methods include reforestation, soil carbon sequestration, coastal blue carbon, and seaweed cultivation.

See also: A Guide to Carbon Dioxide Removal Methods

Sources:
National Academies of Sciences, Engineering, and Medicine 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda. Washington, DC: The National Academies Press. https://doi.org/10.17226/25259.

High-permanence CDR methods sequester carbon dioxide for 1000+ years. Such methods have a significantly stronger ability to contribute to the cumulative "drawdown" of carbon dioxide levels in the atmosphere. High-permanence CDR is generally achieved by using geological storage. Examples include direct air capture (DAC), direct ocean capture (DOC), Biomass with Carbon Removal and Storage (BiCRS) technologies, enhanced weathering technologies, and ocean alkalinity enhancement (OAE) technologies. Some of the sub-variants of these methods are more advanced than others. On a per-ton-removed basis, these methods are generally costlier than low-permanence solutions unless accounting for permanence.

Figure 2: Direct Air Capture



Note: Depiction of a direct air capture fan unit co-located with underground geologic storage.

See also: A Guide to Carbon Dioxide Removal Methods

Sources:
National Academies of Sciences, Engineering, and Medicine 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda. Washington, DC: The National Academies Press. https://doi.org/10.17226/25259.

Between these two ranges are some CDR methods that in their current form tend to sequester carbon dioxide for more than 100 years, but which are expected to release a significant amount of carbon dioxide or completely degrade within or approximately around 1000 years. The time it takes for degradation to occur varies among these methods and within applications of each method. These mid-range methods include biochar, tree burial, and seaweed sinking.

B. System Type and Measurability

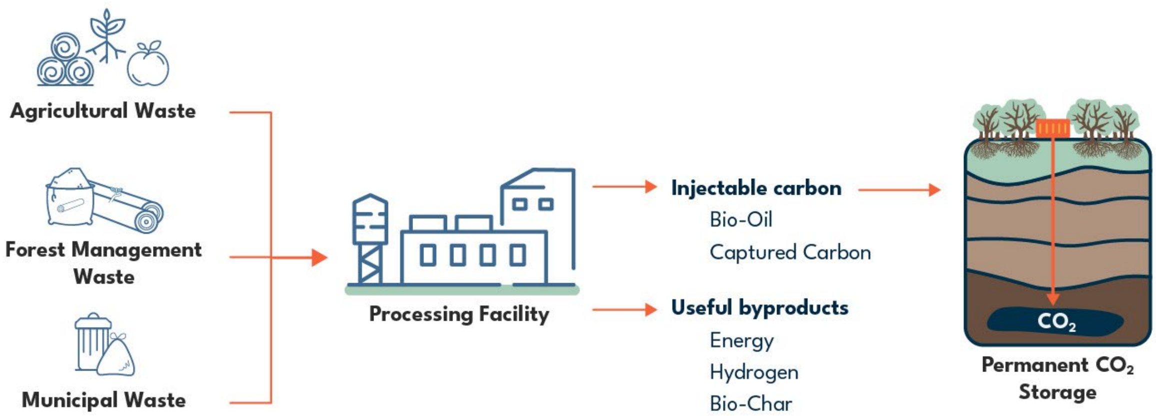
Another distinction among CDR methods is the contexts within which they operate, which affect their measurability. Many high-permanence methods operate in what are known as "closed systems" in which inputs and outputs are easy to observe and quantify. This makes it easier to assess the amount of removal achieved. These types of assessments are referred to as measurement, reporting, and verification (MRV) assessments.

Other CDR methods operate in what are known as "open systems" in which there are many unaccounted-for variables that can differ project by project based on the environment the project occurs in and the materials used.[10] Examples of these variables are the rate of ocean carbon uptake, the rate of rock weathering, and the rate of deep ocean water circulation.[11] This makes it harder to observe and quantify all the inputs and outputs. Although robust scientific literature supports the theory behind how removal occurs, MRV for some methods is still challenging. There are ongoing efforts to improve the rigor of MRV for all methods.

C. Technological Readiness

Technological readiness varies among CDR methods. Low permanence nature-based solutions have limited-to-no technological needs, which makes them easier to implement than some other methods. Some high-permanence solutions such as DAC, Bioenergy with Carbon Capture and Storage (BECCS), and Bio-oil Injection are largely in the deployment phases of the RD&D cycle and have high technological readiness. World-wide, 18 Direct Air Capture facilities are already operational and 50+ BECCS projects have been green-lighted.[12 13]

Figure 3: Biomass with Carbon Removal and Storage



Note: Depiction of the general process shared by several biomass with carbon removal and storage techniques. From the left to right the following are pictured: waste biomass materials that contain carbon, a facility that can process those carbon rich biomass materials, a list of products created from that processing including injectable carbon and other useful products, a depiction of the created injectable carbon being injected into secure permanent underground geological storage.

See also: A Guide to Carbon Dioxide Removal Methods

Sources:
National Academies of Sciences, Engineering, and Medicine 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda.

Washington, DC: The National Academies Press. https://doi.org/10.17226/25259.

D. Sandalow, R. Aines, J. Friedmann, C. McCormick, D. Sanchez. 2020. Biomass Carbon Removal and Storage (BiRCS) Roadmap. Innovation for Cool Earth Forum.

However, there are many more CDR methods — and in particular high-permanence CDR methods — that are still largely in the research and development stage despite some early commercialization. These methods may prove to be easier to scale in the long term or provide valuable co-benefits. For example, many of these methods are less energy- or land-intensive than other CDR methods.

D. Cost

It is also important to note the current cost differences among different CDR methods and the tradeoffs that come along with those differences. Currently, some low-permanence and low-measurability solutions cost dramatically less than high-permanence and high-measurability solutions. This can make the former appear to be a more desirable investment even if both have value from a climate impact perspective.

However, there is every reason to believe that cost factors will change over time, as high-permanence solutions achieve scale and as the price and availability of inputs such as energy, land, and minerals shifts.

E. Non-Removal Impacts

CDR methods have a range of impacts beyond carbon removal. Some of these impacts are positive, such as generation of energy, waste management, soil health improvements, and biodiversity conservation. However, depending on how they are implemented, many also have the potential to have negative impacts. Negative impacts can include excessive resource use, energy use (and associated pollutant emissions), excessive land use, and habitat destruction.

III. CDR Method Tradeoffs and Technology Neutrality

Given the numerous tradeoffs in permanence, measurability, technological readiness, cost, and non-removal impacts that exist among CDR methods it is unlikely that one CDR methods will be able to meet the full need for CDR projected by the IPCC or the Rhodium Group. For this reason, existing CDR investments, such as the advance commitment made by Frontier, has taken a tech-neutral approach by making purchases that span a broad portfolio of CDR methods. Frontier is an advance market commitment by a consortium of businesses that have committed to purchasing nearly a billion dollars in permanent carbon removal between 2022 and 2030.[14]

IV. The Economics of CDR and Existing Policy Support

A. The Economics of CDR

The growing private sector interest by Frontier and others in accelerating the development of high-permanence CDR methods is promising and has proved crucial in developing these methods thus far.[15] However, there are still significant economic obstacles to scaling CDR activities.

First, there is not a "natural" market for most CDR activities because such activities generally do not create a sufficient private benefit for the investor to justify the entire investment in the activity. In this way, CDR is distinct from other types of climate change-mitigating activities that produce substantive volumes of electricity, energy efficiency, transportation fuel or other goods or services valued in the private market. Most CDR projects, by contrast, only produce removals, which are a public good that has diffuse benefits. Although a subset of CDR methods can create energy as a co-benefit (such as BECCS projects), the cost to achieve removals still exceeds the revenues available from energy sales for most such projects. Accordingly, absent some kind of valuation of removals, CDR projects lack a direct, self-sustaining market.

Certain state, regional, and international climate programs credit removals by CDR projects (typically in the form of nature-based CDR), thereby creating a regulatory incentive for investment in CDR. However, entities that have regulatory obligations under those programs typically have lower cost means of compliance than CDR.

CDR can also benefit from the voluntary carbon market. In this market, individuals and companies who are trying to mitigate the climate impact of the goods and services that they make, or use, can purchase credits. However, in the voluntary carbon market, CDR also competes with lower-cost offset options. In addition, the value of a CDR "credit" in such a market is that it offers the buyer the opportunity to offset its own emissions. However, an offset does not equate to a net removal. For this reason, voluntary carbon markets do not provide a long-term economic model for scaling CDR to meet the full scope of need.

For these reasons, direct government investment is a necessary supplement to private purchases motivated by government regulations or voluntary carbon markets. For early-stage methods, government support can take the form of grants. For later-stage methods that are scaling and need consistent reliable funding, government support can take the form of procurement or tax subsidies.

B. Existing Federal Policy Support

There are existing small-scale federal grant and procurement programs for CDR.[16] For several years, Congress has supported initiatives to improve research, development, & demonstration (RD&D). Most recently, the Fiscal Year 2023 appropriations bill instructed the Department of Energy (DOE) to use $140 million of its overall budget for CDR-related efforts and to use part of its overall budget to develop a small-scale CDR pilot procurement program. The bill appropriated funds to other federal agencies for narrower CDR RD&D efforts.[17]

C. Beyond 45Q

Crucially, last year, the Inflation Reduction Act (IRA) revamped the Section 45Q Tax Credit for Carbon Oxide Sequestration; as part of this overhaul, Congress enhanced provisions related to direct air capture (DAC), one CDR method.[18] As originally enacted, the 45Q credit was only available for point-source capture of carbon dioxide emissions from power plants or industrial facilities. In 2018, the Bipartisan Budget Act expanded 45Q to include CDR activities, but it narrowly defined the category so that only Direct Air Capture (DAC) projects would be eligible for the same credit provided to carbon capture projects. The Inflation Reduction Act amended 45Q to increase the value of the credit for DAC projects to $180 per ton sequestered, provided they meet wage and apprenticeship requirements.[19] A Rhodium Analysis released prior to the change found that such a change would significantly impact the ability of DAC to scale in gigaton capacity and possibly bring the removal cost of some forms of DAC under the credit value.[20]

D. Increasing Support for CDR in the Tax Code

While the addition of DAC to the 45Q tax credit and the subsequent increase in the value amount are large steps forward in federal support for CDR, the direct benefits of these changes are limited almost exclusively to DAC projects. Non-DAC forms of CDR are not eligible for the max credit for 45Q because they do not fit the definition of DAC in 45Q. A limited number of CDR forms are eligible for the point source capture credit in 45Q, but that credit value is significantly lower than the DAC credit value. This disparity could potentially lead to unintended impacts and disparities in removal cost after accounting for the different credit values. Additionally, most CDR methods are entirely ineligible for 45Q. Given the need for investment in multiple forms of CDR, a new tax credit is the best way forward.

A new incentive will give policymakers a clean slate to design the program to reach new and promising forms of CDR. A new tax credit can also integrate important policy measures not found in the current 45Q that would better maximize the climate benefits of CDR. For example, a new tax credit could go beyond existing standards for the process of measuring the greenhouse gas impact of an activity – known as a "lifecycle emissions analysis" – to fully account not only for removals but also any GHG emissions attributable to the CDR activity itself. Designing a new tax credit will also ensure that any uncertainty caused by major changes to 45Q does not impact those who currently qualify for it.

PART TWO: Policy Design Considerations and Trade-Offs

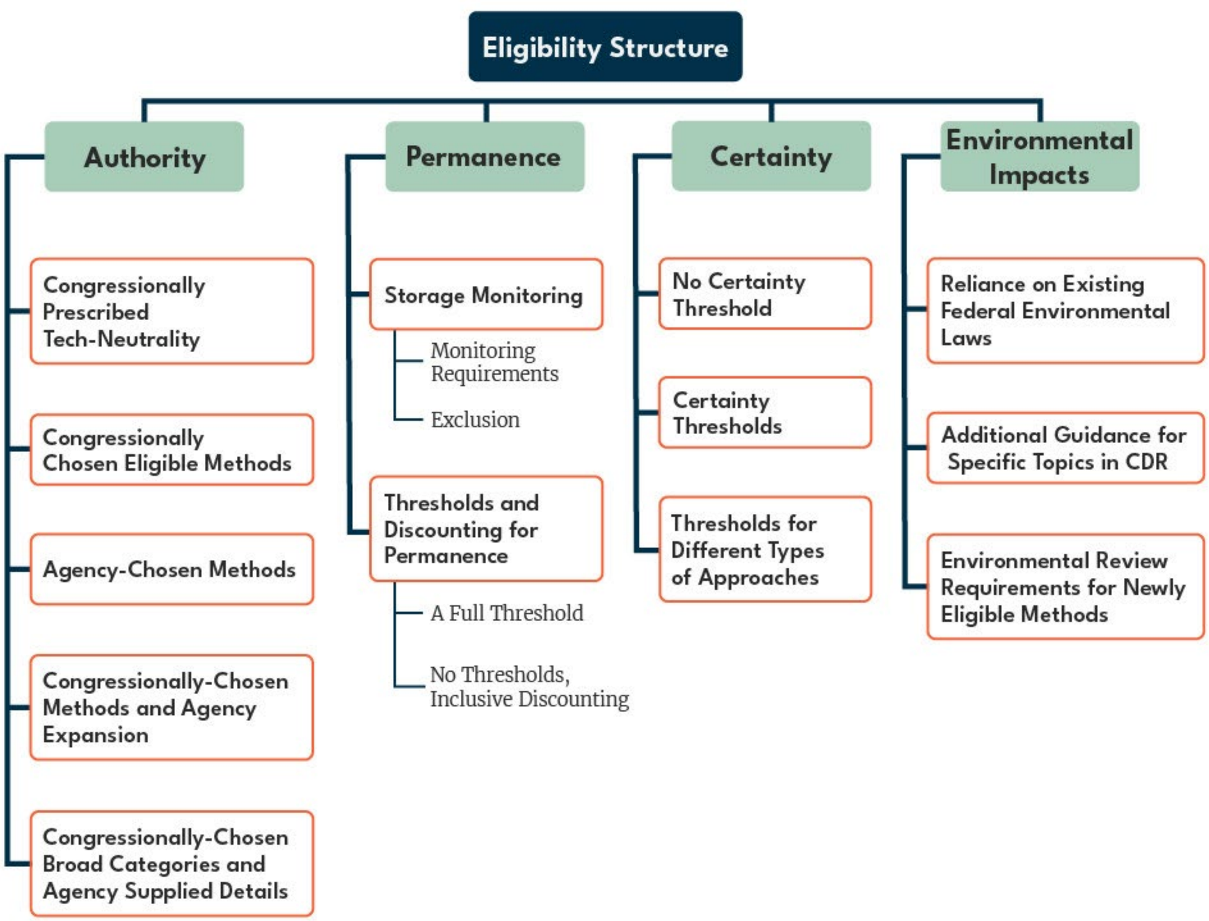
I. Eligibility Structure

The first question in designing a new CDR tax credit is "what CDR projects should be eligible?" There are two primary sub-questions that underly this question:

1. Who will have the **authority** to determine eligibility?
2. Whether and how characteristics that differentiate CDR methods such as **permanence, measurement certainly, and environmental impacts** should be considered?

The sections below delve into each of these questions and outline options for approaching each. Those options are summarized in the below diagram.

Figure 4: Eligibility Structure Design Elements and Options



Note: Visual description of design elements that will need to be considered as part of a CDR tax credit eligibility structure. The green boxes describe the primary design choices that will need to be made and the orange outlined boxes describe the options for each choice. Unboxed text describes sub-options. All options are described in detail in the eligibility section of this paper.

A. Authority

Deciding who will have the authority to determine eligibility for the tax credit will have cascading effects across all of the other considerations that underly eligibility determination. First and foremost, there are existing legal restrictions on the degree to which authority can be delegated to agencies. Beyond these restrictions, there are also trade-offs between administrative responsiveness, method inclusivity, and administrative burden.

Option 1: Congressionally Prescribed Tech-Neutrality

Congress could establish a general, technology-neutral eligibility and reward structure by simply awarding a set quantity of dollars per ton removed for any activity that fits a broad definition of "carbon dioxide removal."

This approach would mirror the approach that Congress adopted in enacting the new 45Y and 48E tax credits for renewable energy, which will replace the technology-specific tax credits for wind and solar projects. Depending on how the criteria for a valid "carbon dioxide removal" activity is defined in statute, this approach may still require significant rulemaking to occur at the agency level. Depending on the level of expected agency clarification needed for this approach, some CDR methods may not be able to discern if their methods and specific method subvariants would be eligible for the credit while rulemaking is underway.

Option 2: Congressionally Chosen Eligible Methods

Because CDR strategies are in various stages of development, it could be helpful to have some variation in requirements and credit values for different types of CDR activities. One approach to distinguishing CDR activities would be for Congress to establish an exclusive list of eligible methods in statute. This model would have an eligibility structure similar in concept to the one in 45Q, which specifically identifies DAC as an eligible method. It would also provide the most certainty for key CDR stakeholders: developers selecting projects, investors, and the agency or agencies implementing the program. Congress might also prefer this approach as it may be reluctant to delegate too much authority to the Executive Branch to define eligible projects – particularly in the context of tax credits.

The downside of establishing an exclusive list of methods is that it could have the effect of "locking out" innovation while "locking in" particular methods and project methodologies. Legislators may err on the side of caution and omit still-developing methods. Even though Congress could always add in other methods later, the bar for congressional action is quite high.

Option 3: Agency-Chosen Methods

Alternatively, Congress could delegate certain elements of eligibility determinations to a federal agency with the requisite expertise. In other words, instead of listing particular CDR methods as eligible, the statute could outline criteria for eligibility, and authorize an implementing agency to interpret and implement those criteria with respect to project applications.

This approach could ensure that new and emerging methods are eligible for the incentive, and the flexible eligibility standard would provide an incentive for further development of promising methods.

Delegating eligibility decisions presents a few risks, however. For instance, faced with a broad delegation of authority, an agency might decide that a narrow interpretation of the statute is the safest way to avoid legal challenge. Creating a program from scratch with little direction from Congress is a resource-intensive endeavor, so Congress would also need to provide adequate administrative funding to support implementation. Moreover, a broadly worded statute would invite substantial public input, including from those seeking to water down standards or obtain funding for projects that may be problematic (e.g., unlikely to get off the ground, ineffective at removing carbon dioxide, etc.). Finally, too much administrative flexibility can cast a shadow of uncertainty over rules and standards. Such uncertainty can discourage investment in projects that will deploy over a longer period.

Option 4: Congressionally Chosen Methods and Agency Expansion

Congress could also take a hybrid approach: establish an initial "whitelist" of eligible methods in the statute and delegate authority to an agency to expand eligibility to additional methods and methodologies, subject to certain criteria.

This is the approach used by the 48C Qualifying Advanced Energy Project Credit. The 48C tax credit includes definitions for multiple types of eligible technologies, but also gives the Treasury Secretary the authority to determine that others are also applicable. In addition, 48C contemplates a role for DOE in reviewing "concept papers" submitted by developers of potential projects. Based on its review, DOE can issue a recommendation to the Treasury Secretary.[21]

Some of the risks highlighted above would still be present but would be mitigated by the hybrid design. For instance, under the hybrid approach, Congress could allow a range of methods to proceed immediately (those "whitelisted" in the statute), thereby addressing the risk that an agency might be too restrictive in its interpretation, while preserving its authority to rigorously review other methods and method subvariants for possible consideration.

Option 5: Congressionally Chosen Broad Categories and Agency-Supplied Details

Under another hybrid approach, Congress could establish broad categories of eligible project activities and direct the agency to provide more eligibility specifics in implementing regulations.

The Renewable Fuel Standard (RFS) provisions in the Clean Air Act are an example of this kind of division of labor between Congress and the EPA.[22] The RFS program is not a tax credit program, but rather, involves a close cousin: tradable regulatory credits. Under the RFS, EPA issues the credits for the production of gallons of biomass-based fuels used for transportation purposes. The RFS statutory provisions establish broad categories of eligible biofuels, which are differentiated by the extent to which their lifecycle greenhouse gas emissions are lower than the conventional gasoline or diesel alternative.[23] Over time, the EPA has allowed fuel producers to petition for "pathways" in which the agency affirms the lifecycle emissions attributed to certain feedstocks, production processes, and fuel types. These pathways are specific to production techniques. However, once EPA has approved a pathway, other producers may use it to expedite approval for their own production techniques.[24] The pathways are the agency's mechanism for determining credit eligibility, e.g., whether a gallon of a particular biofuel is eligible for an "advanced biofuel" credit or a more valuable "cellulosic biofuel" credit.

There are non-energy examples in the tax code of agencies implementing expansions of eligibility through their authority to interpret statutory terms. For example, the Low-Income Housing Tax Credit includes criteria for what is an eligible project. However, there are several other juncture points at which agencies and states apply a role in expanding or restricting eligibility for the tax credit. The Treasury Department has expanded eligibility for the credit by using its interpretive authority to adjust definitions. Additionally, the Census Bureau generates data based on surveys and statistical choices it makes and then the Department of Housing and Urban Development makes determinations that affect eligibility based on that data. The Department then uses this data to make state-level allocations for the tax credit. States are allowed to set additional requirements that apply to their distribution of the tax credit.[25]

This approach would once again create some uncertainty for investors as initial rulemaking takes place. Long term investor certainty would be impacted by how much authority the statute grants to the agency to set eligibility specifics and how the process for achieving eligibility is ultimately structured.

B. Measurement Certainty

A possible component of a CDR tax credit is upfront eligibility restrictions based around certainty of achieving removals. The primary alternative is considering certainty as a factor in calculating a credit value. The below options describe how certainty could be handled as a component of eligibility; options for considering it as part of the credit value are considered later in this paper.

Option 1: No Certainty Threshold

One option is to omit any certainty threshold from the eligibility requirements. Tax credits are frequently awarded for practices with an element of uncertainty.

Outside of the environmental space, tax credits for making specific types of investments, such as investments in retirement savings held in markets, can be viewed as having an element of uncertainty. An example is the so-called "Savers Tax Credit" which is awarded to individuals for their investments in various types of retirement accounts.[26] There is no way of ensuring particular savings from the tax credit because savings ebb and flow based on market factors; instead, the objective is to generally promote saving for retirement.

Option 2: Certainty Thresholds

There may not be an appetite amongst policy makers for substantial uncertainty about performance. In this case, a new tax credit could impose a minimum threshold for certainty of removal.

Because certainty of removal is generally expressed in ranges for particular CDR methods, legislation would need to establish a way of choosing a specific point within that range to compare to the threshold or it would need to delegate that responsibility to an agency.

At minimum, an agency would likely need to evaluate CDR methods to determine ranges for certainty for different methods. A petitioning system or a running requirement for an agency to evaluate certainty could be used to facilitate the determination of new ranges as technology evolves. Alternatively, those claiming the tax credit could be asked to supply a value for removal certainty.

Option 3: Thresholds for Different Types of Methods

Careful consideration would need to be given to choosing a minimum threshold. As discussed earlier, many CDR methods that may prove to be key components to meeting removal needs in the long term have inherent uncertainty issues. Excluding them entirely from a CDR tax credit by setting a minimum certainty requirement could diminish the impact of the tax credit on net removals in the United States.

To accommodate methods that exist in systems with numerous variables that are hard to control and therefore difficult to achieve a high level of measurement certainty for, multiple minimum thresholds for certainty could be created for different CDR methods. This could also be tied to different base credit values.

C. Permanence

As discussed above, CDR methods vary in the extent to which they ensure that removals achieved are permanent or at least of long-term duration.[27] In some cases, it is feasible to rely on MRV methods to verify permanence for at least some period of time. For example, with appropriate monitoring a high level of certainty about the permanence of methods that use underground injection of carbon dioxide as a form of storage can be achieved.

However, this is not always the case. There are methods that can achieve long-term permanence with proper maintenance, but there is a significant lack of certainty that maintenance will take place. For example, soil can sequester carbon for long periods of time, but because soil is likely to be disturbed during a climatically relevant timescale (land ownership and land use frequently changes), it is unlikely it will achieve its maximum sequestration potential.

There are also instances where it is possible to establish a range for permanence of a CDR method, but there are underlying scientific uncertainties that make it hard to understand exact permanence. This is the case for methods that use the sequestration of carbon rich plant or algae material in the deep ocean or deep underground as a storage mechanism.[28] [29]

For these reasons, it is important to consider how to set a threshold for permanence and how to implement monitoring requirements. These two considerations and options for approaching both are explored below.

Consideration 1: Thresholds and Discounting for Permanence

A new tax credit could be designed with only the goal of supporting high-permanence CDR methods or alternatively it could be designed to include other CDR methods.

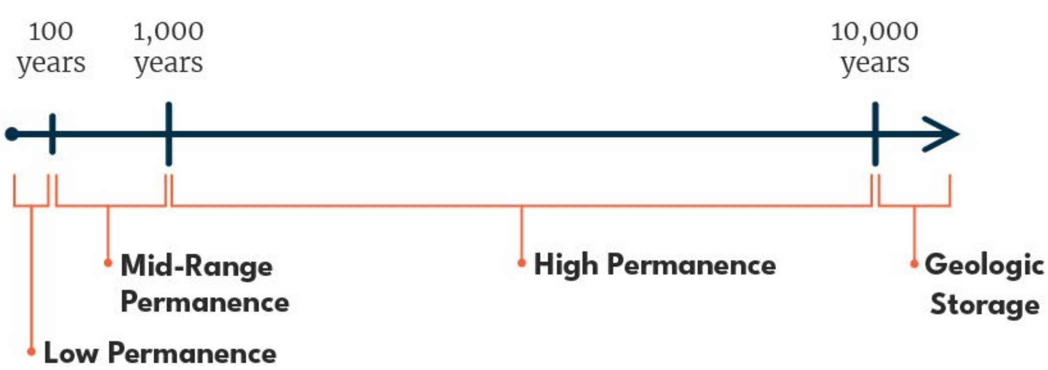
Option 1: A Full Threshold

To account for permanence, the simplest approach would be to set a threshold and deny the tax credit to any CDR methods that cannot provide assurances of reaching that threshold. A variation on this option would be to create multiple thresholds and to alter the credit value based on the established threshold.

Implementing this approach meaning contending with methods that have “ranges” for permanence. Setting a sufficiently high threshold that allows only for geologic timescale storage could obviate this issue. However, mid-range and low permanence CDR methods pose greater challenges. Explicit project-level MRV and LCA requirements could be used to provide specific data on the expected permanence of a project.

However, even after making these determinations, depending on where thresholds are set, some methods may still fall within multiple ranges. For this reason, it may be desirable to explicitly in statue set a requirement to evaluate eligibility based on a low end, mid-point, or high-end estimate.

Figure 5: CDR Storage Duration Timescale



Note: Illustration of the timescale that different types of removal occur on. Methods that fall into each category “sequester” carbon within the indicated range before a significant amount of carbon is released.

Sources:
A Bergman & A Rinberg (2021) "The Case for Carbon Dioxide Removal: From Science to Justice" CDR Primer, edited by J Wilcox, B Kolosz, J Freeman.

Alcalde, J., Flude, S., Wilkinson, M. et al. Estimating geological CO2 storage security to deliver on climate mitigation. Nat Commun 9, 2201 (2018). https://doi.org/10.1038/s41467-018-04423-1.

National Academies of Sciences, Engineering, and Medicine 2022. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

Option 2: No Thresholds, Inclusive Discounting

A discounting method that does not have any thresholds for permanence is another approach. This approach would inevitably maximize the number of CDR activity types that are eligible for the credit. One of the difficulties in implementing this approach is once again that permanence tends not to be an exact number that can be guaranteed but rather falls within a wide range. It would be difficult to calculate a continuous discount level.

Consideration 2: Storage Monitoring

Option 1: Monitoring Requirements

As a threshold matter, Congress can condition a project's eligibility on meeting specified monitoring requirements, which might differ based on the form of storage. For example, geological storage requirements could be based on the existing storage requirements in 45Q and its implementing regulations. For terrestrial or other methods of storage, different requirements might apply. MRV requirements could be designed to control the possibility of reversibility. These systems would have to allow for the possibility of unavoidable factors such as natural disasters. Appropriate penalties could be set for failing to meet monitoring requirements in the long term such as credit "recapture" to address issues of long-term liability.

Option 2: Exclusion

Alternatively, a new tax credit could exclude storage methods that require long-term monitoring for leakage to reduce the risk of reversibility. This approach would likely mean denying the tax credit for activities that inject supercritical carbon dioxide into sedimentary rock formations, the storage process that is most frequently paired with carbon capture and DAC, and which is considered an eligible form of "secure geological storage" under 45Q.[30] Additionally, depending on the design of the restrictions, it may also close the door to storage processes that are currently being researched and may require some form of short-term monitoring.[31] Thus, if this route is taken, it would significantly limit the overall utility of the tax credit by effectively excluding all subsurface carbon dioxide storage.

Option 3: Tiered Credit Value

A third option would be to tier the credit value for different types of storage. For example, storage methods with low risk of reversal with appropriate monitoring such as the injection of supercritical carbon dioxide could be allowed to claim the credit, but storage methods that do not require long-term monitoring at all could receive a slightly higher credit level. This could be achieved by specifying a percentage amount that the credit value would be increased by for projects that achieve secure high permanence storage that does not require long-term monitoring. This approach would incentivize a long-term switch to lower liability storage methods, while allowing existing storage methods to still be used.

D. Environmental Impacts

Many CDR methods are new, and research on their non-climate environmental impacts is still underway. Some CDR projects may have significant negative environmental impacts. Options for how to bolster environmental protections for CDR. Some of these options can be used in conjunction with one another.

i. Option 1: Reliance on Existing Federal Environmental Laws

Numerous CDR methods have interactions with existing environmental quality laws. These interactions can trigger environmental assessments or in some cases result in certain activities being prohibited outright. For existing techniques, there are juncture points – sometimes multiple – when a project-specific environmental assessment may be required. The below summary table provides some examples of existing interactions. However, a more comprehensive analysis would be necessary to fully understand the degree of interaction. Furthermore, this table only covers established methods, and it is conceivable that new methods may not be subject to environmental reviews under current laws. It is also notable that Congress has recently made significant changes to the NEPA environmental review process and has left open the door to additional changes.

Table 2: Selected Interactions Between Environmental Quality Laws and CDR Methods

High Permanence CDR Method	Selected Existing Interactions with Federal Environmental Laws
Bioenergy with Carbon Capture and Storage	Underground Injection Control Program (Safe Drinking Water Act)/ Federal and state permits for injection (NEPA or state NEPA), Possible federal land use permits (BLM).
Bio-Oil Injection	Underground Injection Control Program (Safe Drinking Water Act)/ Federal (EPA) and state permits for injection (NEPA or state NEPA), Possible federal land use permits (BLM).
Biochar	-
Hydrogen Production from Biomass with CCS	Underground Injection Control Program (Safe Drinking Water Act)/ Federal (EPA) and state permits for injection (NEPA or state NEPA), Possible federal land use permits (BLM).
Biomass Burial	Possible federal land use permits.
Direct Air Capture	Underground Injection Control Program (Safe Drinking Water Act)/ /Federal (EPA) and state permits for injection (NEPA or state NEPA).
Direct Ocean Capture	Marine Protection, Research, and Sanctuaries Act (Ocean Dumping triggered environmental review), Federal and state permits for injection (NEPA or state NEPA), BOEM review for construction in ocean (NEPA)
Terrestrial Advanced Weathering	State and Federal mining permits for material sourcing and use of certain repurposed waste materials.
Ocean Based Advanced Weathering	Marine Protection, Research, and Sanctuaries Act (Ocean Dumping triggered environmental review, EPA Permit), BOEM & US Coast Guard review for construction in ocean (NEPA), State and Federal mining permits for material sourcing and use of certain repurposed waste materials.
Electrochemical Alkalinity Enhancement	Marine Protection, Research, and Sanctuaries Act (Ocean Dumping triggered environmental review), BOEM review for construction in ocean, State and Federal mining permits for material sourcing and use of certain repurposed waste materials.

Note: The pictured table includes selected examples of environmental quality laws that different CDR methods interact with. This list is not meant to be exhaustive.

See Also: Guide to Carbon Dioxide Removal Methods for in-depth explanations of methods listed in the left-hand column.

Sources:

United States, Congress, House. United States Code. Title 30 Mineral Lands and Mining, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

United States, Congress, House. United States Code. Title 42, Chapter 55: National Environmental Policy, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

United States, Congress, House. United States Code. Title 42, Chapter 6A, Subchapter XII, Part C Protection of Underground Sources of Drinking Water, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

United States, Congress, House. United States Code. Title 33–Navigation and Navigable Waters, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

United States, Congress, House. United States Code. Title 43, Chapter 29, Subchapter III: Outer Continental Shelf Lands, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

ii. Additional Guidance for Specific Topics in CDR

Overall, existing environmental quality laws were not designed with CDR in mind and there may be need for additional restrictions and related regulations to ensure that CDR methods do not result in adverse environmental impacts.

For example, policy-makers may prefer to set explicit standards for the types of materials that can be used as feedstocks for CDR methods that use biogenic inputs. Policy-makers might also want to adjust existing regulations governing ocean dumping to tailor them to ocean-based CDR methods.

A new tax credit law could establish new environmental standards as needed. The law could direct expert agencies to promulgate more detailed requirements through implementing regulations.

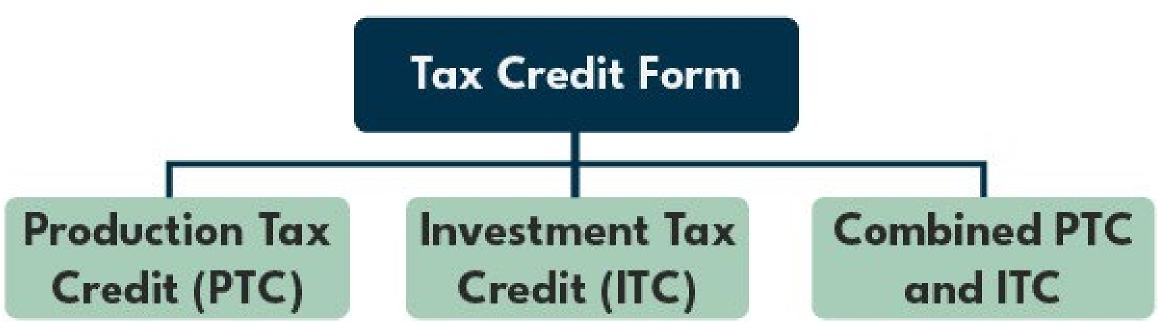
iii. Environmental Review Requirements for Newly Eligible Methods

If a new CDR tax credit law includes a mechanism that allows new methods to become eligible, the law could also include an environmental review component for new methods. Legislation could lay out environmental criteria that a method must meet, delegate an agency to expand upon those criteria, and then require an expert agency to evaluate the impacts of new methods seeking eligibility. As necessary, an agency can define under what circumstances a method would meet congressionally provided criteria.

II. Tax Credit Form

There are multiple types of tax credits that can be used to support CDR methods. These include a production tax credit (PTC) and investment tax credit (ITC).

Figure 6: Tax Credit Form Design Options



Note: Visual description of the options for a credit form for a CDR tax credit. All options are described in detail in the "Credit Form" section of this paper.

Option 1: Production Tax Credit (PTC)

For certain types of CDR projects, it might be sufficient to provide a payment based solely on the amount of carbon dioxide removed. Such a credit would be considered a production tax credit (PTC) wherein a taxpayer is rewarded for producing a certain amount of a given thing – in this case, tons of carbon dioxide removed. Section III.B outlines options for calculating tons removed under a PTC approach.

Option 2: Investment Tax Credit (ITC)

For other types of still-evolving CDR activities, it could be helpful to utilize a project-based payment structured as an investment tax credit (ITC) wherein a taxpayer receives a credit for some percentage of the project's capital costs. An investment tax credit is helpful in offsetting upfront costs – especially capital costs. An ITC can also include a built-in phase-down wherein the amount of the tax credit (and therefore its fiscal impact) decreases as the industry matures.

Option 3: Combined PTC and ITC

These credit models can complement one another: an ITC model might be especially helpful in bringing down the capital costs of certain types of CDR activities while the PTC model provides the more direct way to pay for the public good of removals.

Examples of a technology for which a choice of either a PTC or an ITC is available are solar, wind, biogas, or geothermal. Businesses, non-profits, and local and tribal governments are eligible to receive either type of credit. However, they are not allowed to claim both. A project developer must choose to use either the PTC or ITC on the tax return it files for the year a project is placed in service.[32]

A new CDR tax credit that is designed to allow for an entity to claim either the PTC or the ITC would create a system in which CDR investment is supported by an ITC for projects placed in service during the early development stage when capital costs are high and then by a PTC for projects placed in service when capital costs are lower.

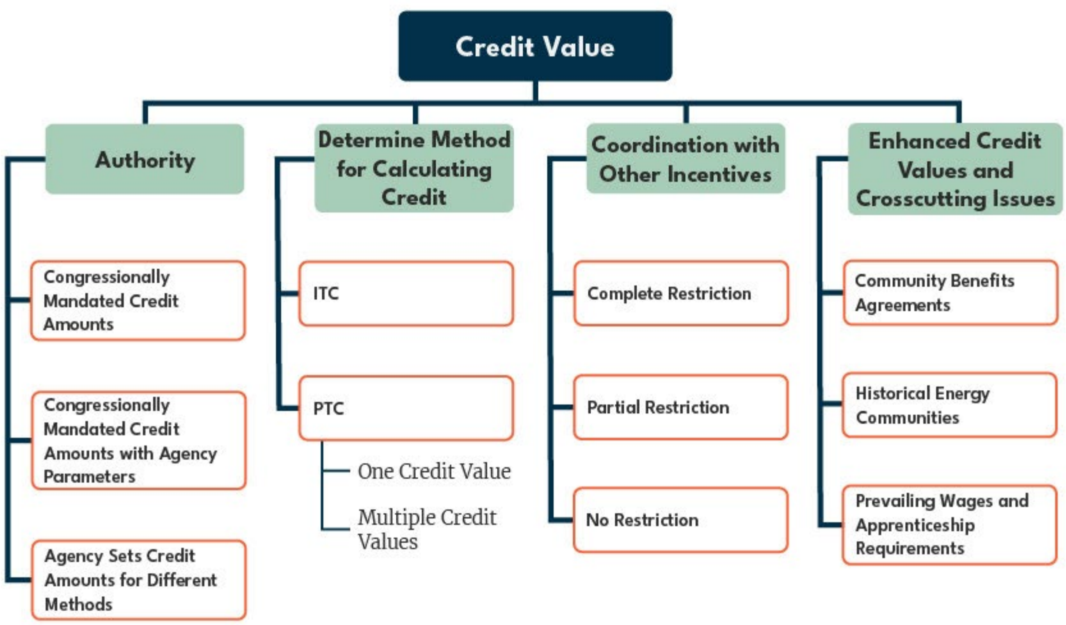
Depending on the size of the credit level, this could be a costlier approach for the federal government. However, an argument could be made that it would be appropriate to support CDR in this manner because CDR is a public good with unique market dynamics. Because many CDR methods may not have significant revenue streams beyond government support for removal, an ITC could reduce the amount of private investment needed for upfront development of CDR methods.

Over time, the emergence of other policies that create a stable market for CDR could also serve as a sufficient incentive for developers to invest in projects without an ITC. Examples of forces that create these dynamics are a PTC with a sufficiently large credit amount to create significant revenue, a well-established federal CDR procurement program, or the existence of government policies that require or encourage private entities to purchase CDR. Any of these policies would create an environment in which CDR activities would follow the normal dynamics of project investment in which entities invest in development of the project based on expected future revenues from production.

III. Setting Credit Value

Policymakers should set the credit value to achieve the multiple goals of a CDR program. The long-term purpose of the program would be to achieve permanent or near-permanent carbon removal at the lowest cost to the taxpayer. However, the near-term objective of the program would be to provide financial support for innovation on CDR methods. Such methods might currently have high costs but hold the promise of achieving high volumes of low-cost removals over time. These trade-offs will need to be considered. The below sections provide an overview of options for how Congress could approach delegating authority for the tax credit, setting the value for a PTC, setting the value for an ITC, and determining whether and how CDR projects should be eligible for multiple tax credits. The below diagram summarizes these options.

Figure 7: Credit Value Design Elements and Options



Note: Visual description of design elements that will need to be considered to design a process for determining the credit value of a CDR tax credit. The green boxes describe the primary design choices that will need to be made and the orange outlined boxes describe the options for each choice. Unboxed text describes sub-options. Options are not always intended to be mutually exclusive. All options are described in detail in the "Credit Value" section of this paper.

A. Credit Setting Authority

The feasibility of the options described below for setting credit value for both an ITC and PTC are restricted by the extent to which Congress is able to or wants to delegate authority to the Executive Branch. The below options outline how Congress could delegate authority to the Executive Branch and the implications of that degree of delegation.

Option 1: Fully Congressional Mandated Credit Amounts for Broad Methods

Congress could set a credit value in statute. This is the approach that was taken for the 45Q tax credit. Notably, the 45Q tax credit applies to multiple practices and there are different values for those practices. There is one level of credit for point-source carbon capture projects and a higher tax credit level for DAC projects. The benefit to this kind of tiered pay-per-ton structure is that the value of the credit can be calibrated to particular characteristics of different CDR methods — such as development costs. The detriment of this structure is that the credit value will not change as the cost of capture decreases, without Congress amending the statute.

Option 2: Congressional Mandated Credit Amounts for Broad Methods with Agency-Set Parameters for Tier Eligibility

Alternatively, Congress could set multiple credit value "tiers" and then delegate some limited responsibility for determining the eligibility of projects for different tiers.

Eligibility in Criteria-Based Tiers: For example, the 45V tax credit for production of "clean hydrogen" establishes tiers for determining the tax credit for a particular hydrogen project. The statute provides a definition of what clean hydrogen is and requires that the determination of the appropriate tier is made based on the results of an LCA. Therefore, the credit value is partially a function of how an agency implements LCA requirements. These requirements, specifically the boundaries set and the LCA standard used, can have a significant impact on the results of the LCA. In the case of CDR, changing the design of an LCA can dictate whether a project has net negative or net positive emissions. Changing the boundaries of an LCA can significantly change the calculation of the emissions intensity of the fuel or feedstock used by a project.

Section 45V provides that a project's LCA should be determined using the GREET model, but also affords the Treasury Secretary the authority to use a "successor model," thereby allowing flexibility if an improved model becomes available. This is an example of a very limited, but impactful way Congress can allow an expert agency to play a role in determining the credit tier for different projects. In the case of CDR, a similar process could be established to take into consideration compliance with LCA and MRV requirements, outcomes from those processes, and other factors such as expected operating costs/capital expenditure, and MRV outcomes.

Eligibility in Factors: Similarly, there are examples of agency involvement in determining factor amounts used for the purpose of calculating a credit value as described above. An example is the 45Z clean energy PTC which uses emissions factors to calculate the credit value. The Treasury Department creates standardized emissions factors for different technologies that are eligible for the tax credit and those emissions factors are used to calculate the credit value.

An example of a non-energy tax credit in which there is significant agency involvement in calculating the credit value is the Low-Income Housing Tax Credit. While there are many specifics included in the tax code for how to calculate the credit, the Treasury Department also has the authority to use a formula of its own design to adjust the tax credit value.[33]

Option 3: Agency Sets Credit Amounts for Different Methods

Congress could also set basic parameters in the statute and delegate authority to an agency to right-size the incentive amount.[34] For instance, Congress could set a maximum credit value and give Treasury authority to reduce the credit value for multiple factors without specifying the value for the adjustment. There is no precedent for this model — a PTC model with a ceiling value but potential for adjustment at agency discretion. Congress could direct Treasury to consult with another agency with the requisite technical expertise to gauge the value of a project based on per-ton-cost-of-carbon-removed and set the incentive level consistent with the terms of the statute.

However, this structure raises a few issues. For instance, even with upper and lower bounds on the credit value, it would be difficult to score the proposal as there is no obvious method for determining how the agency would evaluate projects. Relatedly, if an agency could expand or contract the incentive size then it might also be perceived as delegating revenue and spending authority in violation of Separation of Powers principles.

It is highly unlikely that Congress will delegate authority to Treasury to change the credit value itself beyond some adjustment for certain factors (e.g., LCA scores, expected operating costs/capital expenditure, MRV outcomes, permanence). However, there are existing examples of tax credits where agencies use some authority to alter credit value and eligibility for different credit values.

B. PTC Credit Value Determination

A per-ton PTC would award the credit based on the number of tons removed. Many CDR methods can provide this data for their project on an annual basis with a high level of certainty. However, CDR methods that are still developing accurate **MRV protocols** (i.e., specific guidelines for how to conduct MRV for a method or method sub-variant) would have greater difficulty providing this data with a high level of accuracy. For cases in which an accurate assessment of tons removed is not feasible, adjustments could be made to the quantity of tons removed, decreasing it to account for uncertainty.

PTC credits may also consist of a "base rate" credit value multiplied by the production amount and some sort of multiplier based on meeting additional requirements. Some tax credits also include tiers. Examples of how PTC credit values have been calculated in the past are in the Table below.

Table 3: Selected Example of PTC Tax Credits

45U Nuclear PTC	45Q Sequestration PTC	45V Hydrogen PTC	45Z Clean Fuel PTC
Total Credit Value = Reduction amount – (.03*electricity sold).	Establishes different base credits for different types of sequestration, unique requirements for some credit levels.	Total Credit Value = produced amount of hydrogen*base rate*applicable percentage.	Total Credit Value = (Base Amount or Alternative Base Amount)*Fuel Sold*Emissions Factor.
Reduction amount = total revenue from sold electricity/0.025*electricity sold.	Multiplier for wage and apprenticeship requirements.	Establishes four tiers for credit values based on LCA determined emissions that correspond with applicable percentages.	Emissions Factor = (50 kilograms – emissions rate)/50 kilograms.
Annual adjustment by an inflation factor.	Annual adjustment by an inflation factor.	Multiplier for wage and apprenticeship requirements.	Emissions rate is determined by agency, can petition if a rate is not yet established.
Multiplier for wage requirements.		Annual adjustment by an inflation factor.	Annual adjustment by an inflation factor.

Note: The components of four existing energy tax credits are summarized in the pictured table. These credits were chosen to demonstrate the variety of design types in existing energy tax credits. This is not an exhaustive list of energy tax credits.

Source: United States, Congress, House. United States Code. Title 16, Subtitle A, Chapter 1, Subchapter A, Part IV, Subpart D–Business Related Credits, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

All of the above tax credits have been tailored in some way to integrate features of the type of production that they are incentivizing. A pay-per-ton PTC for CDR would award the credit based on the number of tons removed. Some of the specific considerations for which Congress may want to adjust include **measurement certainty, storage permanence**, and **project cost.**

All of these factors impact the comparability of methods. If measurement certainty is not accounted for in the credit amount or alternatively in underlying data reported from the MRV process, then one "ton" of removal for one method may vary considerably from another "ton" of removal for another method. Similarly, if one method has significantly lower permanence then it does not necessarily achieve removal to same degree as a method with higher permanence.

Below are options that describe how pay-per-ton models could be structured for a PTC.

Option 1: One Credit Value

A pay-per-ton PTC could be simply calculated by multiplying the number of tons removed by a single removal value. This approach would require the developer to measure the amount of removal that takes place at its facility. This crediting approach is expressed in the below equation.

*Removal Amount * Credit Value = Total Credit Amount*

Option 2: Multiple Credit Values

Method-Based Tiers: There could be good public policy reasons for setting different credit values for different CDR methods. An example of this approach is the existing 45Q tax credit, which has one credit level for point-source carbon capture projects and a higher tax credit level for the more expensive, still-scaling category of DAC projects.

While this design option would provide more flexibility, it would require the Congress to determine the needed per-ton incentive for methods that have varying costs and would require Congress to amend the statute in the future to make adjustments as costs change with greater deployment.

*Tons Removed * Tier = Total Credit Amount*

Attribute-Based Tiers: A similar model is the one used for the 45V tax credit for qualified hydrogen projects. Section 45V specifies four credit value tiers based on the emissions rate attributable to production of the fuel. The appropriate tier for a claim is assessed through the results of an LCA. This approach awards projects that achieve the intended goal of the tax credit without entirely locking out projects that have lower efficacy (i.e., higher emissions intensity). This model could be transferred to a potential CDR tax credit by substituting emissions tiers with certainty of removal, level of cost, or another attribute. This approach allows projects and project developers to gain access to different credit levels as they improve efficacy without congressional intervention. This model is expressed in the below equation.

*Tons removed * Tier Percentage * Credit Value = Total Credit Amount*

Emission Factors: Alternatively, instead of setting tiers in statute, Congress could delegate authority to an agency to determine the credit factor. This would be similar to the 45Z Clean Fuel Production Tax Credit. Section 45Z prescribes some parameters for setting the value of the credit value, but also charges the Secretary of Treasury with choosing and annually publishing the emissions factors for different groupings of similar production methods; these emission factors are the key input for determining the credit level. This process requires the Secretary to determine which production methods are similar enough to use the same emissions rate. It also allows taxpayers to petition the Secretary to establish an emissions rate for a type of fuel not already covered — a process similar to the process through which entities can petition the EPA for a new RFS "pathway." This approach could help increase precision while minimizing the need to update the statute as methods evolve over time. This is expressed in the below equation.

*Removal Amount * Credit Factor * Base Credit = Total Credit Amount*

Pay for Practice: A variation of criteria-based tiers and factors is creating a "pay for practice" style tax credit. This crediting approach may be helpful for CDR methods for which precise measurement of removals is not possible, but it is relatively easy to accurately account for another proxy. This can be done in lieu of a PTC approach or could be established as an option within a PTC. To this end, the PTC's value could be determined based on the extent to which a practice takes place, without measuring the precise removal achieved. The rationale for this approach would be that full implementation of the practice is known to generate removals, albeit within a broad range. Therefore, instead of calibrating the tax credit to tons removed, the tax credit could reward implementation of the practice based on a general assumption that the practice will achieve at least the low end of a range of removal outcomes.

For example, an ex-situ mineralization operation that creates a specified amount of processed rock could receive a credit value for the range of the size of its operation or equal to the amount of rock multiplied by the value of the credit. The credit amount claimed by the operation would be unimpacted by the actual removal.

*Practice Amount * Tier = Total Credit Amount*

C. ITC Credit Value Determination

An ITC would be based on a percentage of a project's actual costs, and therefore could be calculated with precision and obviate the need to calculate exact tons removed. By design, the ITC are more generous for types of CDR activities that currently have higher capital costs and relatively higher uncertainties around the extent of removal.

On the other hand, an ITC shifts a portion of the investment risk from the project developer to the taxpaying public. It also might encourage speculative projects because, without some adjustment, projects for which removal is difficult to estimate would be on roughly equal footing with projects that can sufficiently demonstrate removal. This risk could be somewhat mitigated through the establishment of certain performance standards or by tiering the credit value by project criteria. For instance, the tax credit provision could require projects to achieve a certain minimum quantity of net removal in order to be eligible.

One could also argue that it is appropriate for the public to bear some project performance risk because CDR is a public good and there is a near-term objective to scale CDR activities.[35] Risk might also be viewed from the standpoint of a portfolio approach, wherein underperformance by some projects is offset by the success of others, as is often the case with government-sponsored loan programs.[36] Still, projects that ultimately result in little removal relative to the cost or the amount anticipated could attract criticism.

There are several existing investment tax credits, including the reforestation credit, renewable energy ITC for businesses, and solar ITC for individuals. By nature, these credits come with some varying levels of risk. Some of these credits, such as the renewable energy tax ITC for businesses, have provisions that allow for recapturing a portion of the tax credit if the outcomes of the project fail to meet the requirements for the tax credit after the project is operational or if it never becomes operational.[37]

D. Coordination with Other Incentives

Policymakers will also need to consider the interaction of the tax credit with other government-provided financial incentives available for the project activity (e.g., other tax credits, grant funding, etc.).

Option 1: Complete Restriction

One approach would be a strict requirement that denies eligibility for the credit if the project activity is eligible to obtain support from other government incentives. This would be highly unorthodox for a tax credit.

Option 2: Partial Restriction

Another approach would restrict combining the CDR tax credit with a particular other tax credit(s). An example of such a restriction is a clause in the 45V clean hydrogen production tax credit that prevents claimants of that tax credit from also claiming the 45Q tax credit for facilities with carbon capture equipment.[38] This approach could be used to prevent DAC project claimants from claiming the new tax credit in addition to the existing 45Q tax credit.

Option 3: No Restriction

However, in some cases, it may make sense to allow developers to "stack" a new CDR tax credit with other tax credits. For example, some CDR activities yield not only removals but also another public good for which a different government financial incentive is available.

For example, BECCS projects generate both removals and renewable electricity, which is eligible for federal and state tax and regulatory credits. If forced to choose between incentives, a project developer might either forgo the extra investment needed for removal and only generate renewable electricity; alternatively, the developer might forgo the extra investment in electricity generation and convert to a simple biomass carbon removal and storage (BiCRS) project. Many forms of CDR such as advanced weathering, ocean alkalinity enhancement, and direct ocean capture have variations with the capacity to create carbon-negative hydrogen as part of removal process.

In these types of circumstances, it may make sense to allow the project developer to "stack" the CDR credit with the financial incentives for other types of public goods that the project can deliver. For example, while other tax credits have clauses that bar coordination with the 45Q tax credit, the 45Q tax credit itself does not explicitly prevent the "stacking" of the tax credit with other tax credits.[39]

Table 4: Potential Stackable Tax Credits by CDR Method

CDR Method	Potential Coordinating Federal Incentives
Bioenergy with Carbon Capture and Storage	45Q (carbon capture credit value) 45V (for hydrogen production) 45Y (for electricity production) 45Z (for fuel production) 40B (for Sustainable Aviation Fuel Generation)
Bio-Oil Injection	45Q (possible utilization credit value)
Biochar	-
Biomass Burial	-
Direct Air Capture	45Q (DAC credit value) 45V (for hydrogen production) 45Z (for fuel generation) 40B (for sustainable aviation fuel generation)
Direct Ocean Capture	45V (for hydrogen production) 45Z (for fuel generation)
Terrestrial Advanced Weathering	45V (for hydrogen production) 45Z (for fuel generation)
Ocean Based Advanced Weathering	45V (for hydrogen production) 45Z (for fuel generation)
Electrochemical Alkalinity Enhancement	45V (for hydrogen production) 45Z (for fuel generation)

Note: The components of four existing energy tax credits are summarized here. These credits were chosen to demonstrate the variety of design types in existing energy tax credits.

See Also: "A Guide to Carbon Dioxide Removal Methods" for in-depth explanations of methods listed in the left-hand column.

Source: United States, Congress, House. United States Code. Title 16, Subtitle A, Chapter 1, Subchapter A, Part IV, Subpart D–Business Related Credits, Office of the Law Revision Counsel, 13 Jun. 2023, uscode.house.gov.

E. Enhanced Credit Values and Crosscutting Issues

Many tax credits, especially those established or modified by the Inflation Reduction Act, are claimable at an enhanced value if a project meets additional eligibility criteria. These enhanced values are often expressed as a percentage increase of the base credit.

The below section summarizes project attributes for which policymakers may want to provide an enhanced credit value. Alternatively, Congress could opt to make any of these attributes into eligibility requirements.

i. Community Benefits Agreements

Some CDR projects have localized positive non-climate environmental and environmental justice impacts. Such impacts include addressing ocean acidification, improving soil health, and generating jobs. However, some CDR methods may come with negative environmental impacts that if not properly controlled can impact the communities they take place in.

To address these possibilities and foster community trust in projects, a new tax credit could include requirements related to environmental justice. For example, a credit could require a higher threshold of community engagement or the creation of community benefit agreements for projects.

ii. Historical Energy Communities

The section 45 renewable energy tax credit and section 45Y clean energy tax credit both include an enhancement of 10 percent of the credit value if the facility is located in a community that is defined as an "energy community." These communities include those designated as brownfields, areas that have historically experienced high employment in energy industries and have since experienced a decline in employment, and areas where coal facilities were previously located.[40] A similar enhancement could be made for a new CDR tax credit.

iii. Prevailing Wages and Apprenticeship Requirements

Numerous tax credits – including the 45Q, 45Y, 45Z and 45V tax credits – provide a tax credit value that is five times the base credit value, if prevailing wage and apprenticeship requirements are met. As an alternative compliance method, taxpayer that fails to meet the prevailing wage and apprenticeship requirements is allowed to receive the higher value through the payment of penalties, which effectively reduce the value of the tax credit. The prevailing wage requirements in these credits stipulate that wages for certain jobs cannot be paid at a rate less than the government-determined prevailing wage. The apprenticeship requirements stipulate that a certain amount of labor hours of the construction or modification or a facility must be performed by apprentices.

IV. Accountability

CDR differs from most other climate-related tax credits because the awarded behavior is not something that can always be easily visualized in the way power infrastructure and fuels can be. Our understanding of how much removal has taken place is largely a function of our ability to measure that removal. For that reason, standards of accountability for CDR are of heightened importance.

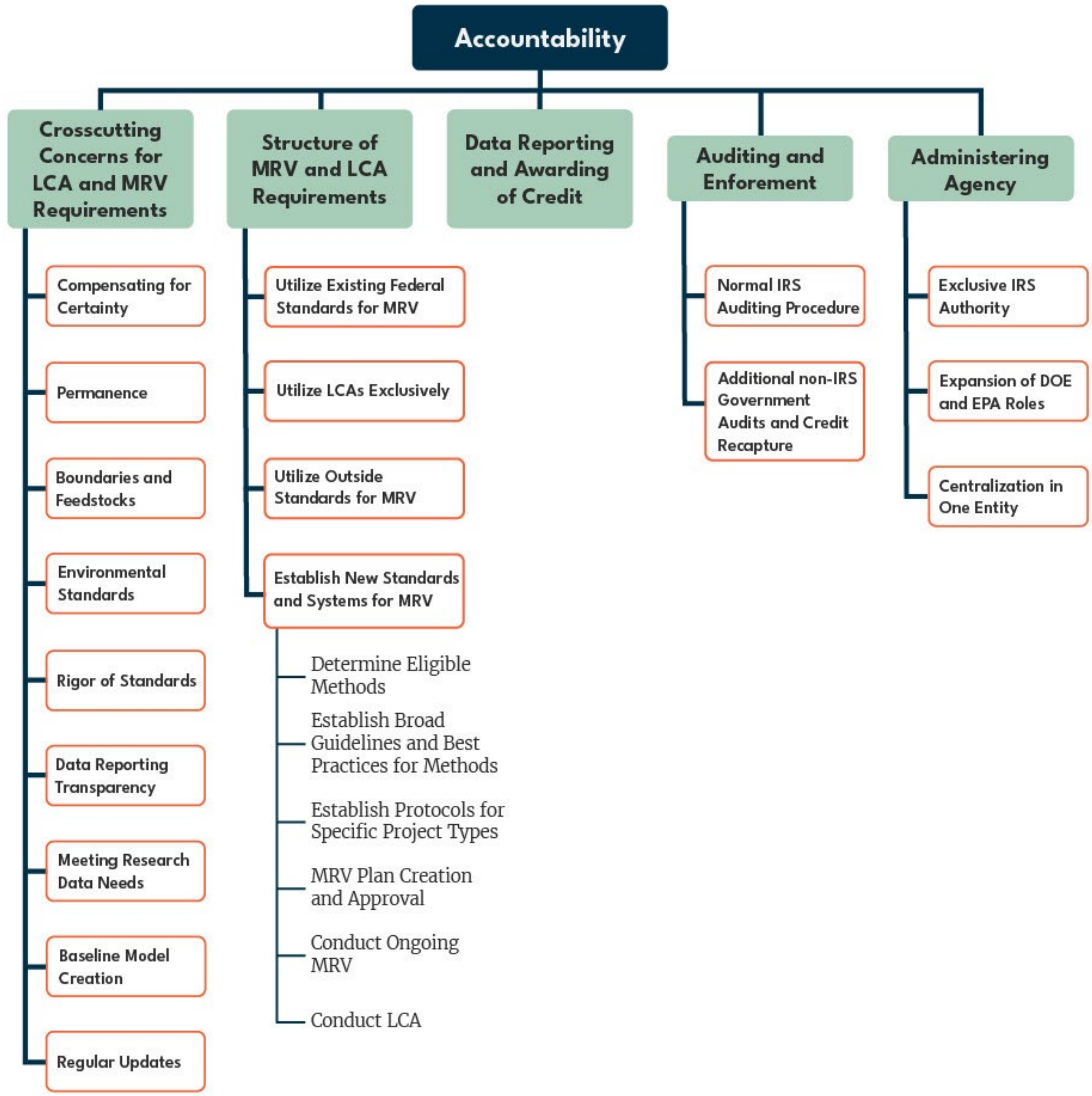
The process for ensuring accountability can broadly be thought of as beginning with conducting an LCA and ongoing MRV. These processes then generate data and narrative information that can be reported. This reported information is then used to award the tax credit to a claimant. This process should ensure to the greatest degree possibility that a credit is awarded appropriately, but as needed they can then be followed by auditing and enforcement actions.

Figure 8: Accountability Process

Note: Visual representation of the primary steps in the accountability process for a CDR tax credit as described in this paper's accountability section.

Each of these individual process components has several steps and authority delegation components that individually could have a significant impact on the overall accountability structure. For this reason, this paper will examine each individually. The below diagram summarizes the sub-options for each process component.

Figure 9: Accountability Design Elements and Options



Note: Visual description of design elements that will need to be considered to design a corresponding accountability process for a CDR tax credit. The green boxes describe the primary design choices that will need to be made and the orange outlined boxes describe the options for each choice. Unboxed text describes sub-options. Options are not always intended to be mutually exclusive. All options are described in detail in the "Accountability" section of this paper.

A. Overview of MRV Requirements

MRV is the process of continuously measuring various metrics for a project to understand its outcomes. In the case of CDR, these metrics are used to yield a value for the overall removal achieved by a project. MRV data can be used to yield various insights on a project. One use of MRV is generating data that can be used for conducting an LCA of an already operational project.

MRV processes are guided by "protocols" that outline how MRV should be performed. Variations in these protocols impact what is and is not measured and the degree of accuracy of those measurements. For that reason, to implement a CDR tax credit with reasonable precision and to ensure consistency in measurement across projects, it is important to use high quality protocols.

MRV protocols are also useful tools for addressing uncertainty in CDR methods. The CDR sector is pressing for the development and implementation of improved MRV tools.[41] However, for some CDR methods, it might never be possible to achieve high levels of measurement certainty.[42] For example, open systems methods, such those based on alkalinity introduction, are often inherently harder to measure with precision because of their diffuseness. These methods have high levels of uncertainty in measurement.

Given the need to utilize multiple methods to achieve CDR removal goals, policymakers will need to grapple with how to address measurement uncertainty in MRV requirements. Failing to do so would exclude some high permanence CDR solutions that could prove to be more cost effective, have higher CDR removal potential in the long term, and the capacity to play a vital role in reaching removal goals. For example, the net removal achieved by removing 10,000 tons with 60% confidence is greater than that achieved by removing 1,000 tons with 90% confidence.

MRV protocols can be used to ensure that the most precise measurement methods are used and makes it possible to adjust the number of tons removed to properly account for uncertainty. This will create more standardization between final removal values and help ensure that the tax credit is claimed appropriately.

B. Overview of LCA Requirements

LCAs assess environmental impacts and emissions of products and projects over the course of their operational lifetime. LCAs can be used to understand the expanded lifetime removal potential of a CDR project. The results of LCAs can be affected by several factors. These include the "boundaries" of the LCA, which define what steps in the development and operation of a project are covered by the LCA. Narrower and wider boundaries can result in different outcomes-based impacts associated with feedstocks and other inputs. Another factor is the choice and availability of factors that are included in the LCA.

Yet another factor is the quality of the underlying data used in the LCA. MRV data for a project can be used to perform an LCA when that project is already operational. In this case, the quality of an LCA is dependent on the quality of underlying MRV. Aside from MRV from the project itself, the accuracy of other data sources used can also affect the quality of an LCA.

Several tax credits ensure uniformity in LCAs by requiring compliance with specific ISO standards, however these standards may not fully capture the full scope of best practices for a specific technology, especially nascent ones. Given the nascency of many CDR methods, ISO standards alone may not be able to fully capture best practices for different methods.

Beyond ISO standards, LCAs are impacted by the systems used to conduct them. LCAs are often conducted using the Argonne National Laboratories GREET model. Federal law and guidance often require the use of GREET. While GREET does undergo updates, the availability of features and factors in the model can impact the way an LCA is conducted.

C. Crosscutting Concerns for LCA and MRV Requirements

i. Environmental Standards

Beyond appropriate accounting for removals, there may be a desire to require the collection of data points on non-climate environmental impacts. These can be used for the implementation of any environmentally focused eligibility requirements as well as for research purposes.

ii. Rigor of Standards

Any accountability standards are only helpful insofar as they are rigorous. Rigor can be hard to legislate and define with consequence. To ensure that standards do indeed meet accounting needs, environmental needs, and are implementable it might be desirable to build in structural checks and external review of standards into their validity. For example, the statute could require the creation of an external expert advisory panel, a community engagement panel, and ongoing evaluation by a separate government or quasi government entity with technical expertise such as a National Laboratory or the National Academies of Sciences. This model has been used in other contexts, such as the Census Bureau's execution of the Decennial Census.

iii. Data Reporting Transparency

Large quantities of data will need to be reported for the purpose of administering a CDR tax credit. Making this data publicly available to the greatest degree possible would provide greater transparency and likely accountability. Additionally, the data could help inform overall understanding of CDR methods and aggregate U.S. GHG emissions.

iv. Meeting Research Data Needs

Because many carbon removal techniques are still nascent, there would be a significant scientific benefit to using a tax credit to not only incentivize removal, but also to incentivize data collection on carbon removal for research purposes.

v. Baseline Model Creation

To fully understand the extent to which carbon removal is achieved, it is necessary to understand baseline carbon dioxide levels in a system. Requiring that an administering agency establish and create models as needed to understand baselines will help maximize accountability. Such models are expensive, and it would present jurisdiction issues if funding for their creation was included in tax legislation. For this reason, it might be prudent to provide funding for baseline modeling through separate legislation.

vi. Regular Updates

It is also notable that there is significant scientific focus on improving MRV.[43] To incorporate any gains in knowledge about best practices for MRV that may emerge, it would be useful to require regular reviews of existing protocols and general overall guidance on MRV above the protocol level. This will help ensure that projects are not tied down to outdated methods.

vii. Compensating for Certainty

To fully calculate removals achieved by a CDR project, it is important to have a strong grasp on certainty of measurement of removal. Removal values could be adjusted for certainty in a uniform manner as part of the MRV process. This would yield comparable data on tons removed. This incorporation into reported data would obviate the need to factor in uncertainty into credit values. Simply multiplying a chosen base credit level by the tons removed value would be adequate. A requirement to incorporate measurement uncertainty into reported data could be written in statute.

viii. Permanence

An additional concern that should be taken into account in both MRV and LCAs is accounting for permanence. In the case that a tax credit has a requirement for ensuring a certain number of years of storage or sequestration, requiring reporting on permanence as part of MRV and LCAs will be crucial for the administration of a tax credit. Particularly in the context of MRV, when considering permanence, it is also important to consider and take appropriate measures to prevent any possibility of leakage.

ix. Boundaries and Feedstocks

Because the primary objective of carbon removal is to achieve net negative emissions, it is of crucial importance that LCAs have sufficiently wide boundaries that capture emissions attributable to feedstocks used in a CDR project, such as energy inputs. A failure to account for emissions related to feedstocks or inappropriately accounting for them can result in carbon positive processes appearing carbon negative.

D. Structure of MRV and LCA Requirements

Beyond consideration of the previously discussed cross-cutting concerns, consideration should also be given to the structure of the MRV and LCA process. The below options summarize different approaches and their implications.

Option 1: Utilize Existing Federal Standards for MRV

For numerous CDR methods, there are no existing federal MRV protocols. Consequently, relying only on existing federal standards would significantly limit the scope of the tax credit. Additionally, there may be a desire to go beyond existing EPA protocols to tailor them for the purpose of implementing the tax credit.

The existing 45Q tax credit has a requirement to engage in MRV, however the scope of the tax credit almost entirely aligns with available existing MRV protocols for geologic sequestration of carbon dioxide that exist for the implementation of EPA's Greenhouse Gas Reporting

Program (GHGRP). The IRS has deferred to the EPA standards for implementing 45Q. In so far as projects comply with EPA GHRP MRV requirements they meet the MRV requirements for the tax credit.

For this reason, a new CDR tax credit that goes beyond underground geological storage and has a MRV requirement would need to make room for the development of new MRV protocols.

Option 2: Utilize LCAs Exclusively

Conducting an LCA is required to claim the utilization credit under the 45Q tax credit. To meet this requirement, the IRS requires projects claiming the credit to submit LCAs on an annual basis to the IRS and DOE for each utilization facility. DOE provides technical review and approval of LCAs.

Additionally, other tax credits such as 45V have LCA requirements instead of MRV requirements. However, notably, LCAs are used in that context to slot projects into broader tiers, not to determine the production amount.

While LCAs are frequently explicitly required in the tax code, given that MRV values are used to conduct LCAs for already operational projects and that LCAs are intended to cover the full lifecycle of a project not removals for a specific year, requiring only an LCA may prove to be insufficient to ensure accountability.

Additionally, it is important to note that there may be a desire to create requirements beyond what are currently covered in ISO standards or available in the existing GREET model. These expanded standards could co-exist with utilization of ISO standards and could be optimized to different methods and require the reporting of information that otherwise not be furnished.

Option 3: Utilize Outside Standards for MRV

There are existing MRV protocols for CDR methods that have been set by non-government third party standard setters. However, there are significant concerns about the accuracy and validity of these protocols. For example, the California Cap and Trade Program has deferred to third party standard setters to set MRV protocols for forestry-related credits administered under the program. However, a recent analysis that evaluated forest management removals certified by these standard setters found significant issues with their certification protocols.[44]

Considering concerns about third party standard setters and critiques of government programs that have used them in the past, this approach may be suboptimal.

Any MRV protocols established for a PTC would have a direct impact on the total claimable amount for a project. Using standards that have low accuracy could result in the credit being inappropriately claimed. Additionally, policymakers may be apprehensive or find it inappropriate to delegate standard-setting authority to non-government entities. While there is a role for non-governmental entities in proposing MRV protocols to the federal government, the government should have the final word on evaluating and determining the requirements for such protocols.

Option 4: Establish New Standards and Systems for MRV

Establishing high level MRV guidelines and more specific MRV protocols through the federal government can help maximize the precision and standardization of MRV and thus assure that credits are claimed appropriately. This option will, however, require the federal government to take on an additional administrative burden.

There is a broad array of existing CDR methods and new ones are likely to be developed. All of these different methods will need different protocols. Furthermore, protocols often need to be tailored to specific CDR projects. For this reason, the process of establishing MRV guidelines and protocols will need to be an ongoing administrative process. A theoretical process could involve the below components.

i. Determine Eligible Methods:

Before standards can be set for different CDR methods, eligible CDR methods for the tax credit will need to be identified, as described earlier in this paper. When a new method is deemed eligible, as the result of petitioning process or otherwise, it would also trigger the creation of MRV protocols for the purpose of administering the tax credit. As discussed earlier, to ensure technology neutrality and easy integration of emerging methods it would be helpful to create a petitioning process to add new methods.

ii. Establish Broad Guidelines for Methods:

MRV: MRV protocols ultimately will need to be tailored to specific method subvariants. However, there are significant similarities that can be expected between projects of the same general method. For this reason, it may be desirable to develop overarching MRV guidelines that cover multiple sub variants within a CDR method. These method-specific protocols will be especially helpful for integrating the crosscutting issues between MRV and LCAs that will be explored later in this section.

LCA: While a chosen LCA standard, such as an ISO standard, can cover a broad swath of CDR methods, because of the crosscutting issues described, there will likely be a need to set guidelines for how to conduct LCAs for different methods that go beyond any chosen LCA standard. These guidelines would be particularly helpful for setting appropriate boundaries for a tax credit. Setting these broad standards can also serve as a means of identifying factors that will need to be added to the existing GREET model. Setting broad guidelines will also provide an opportunity to create requirements beyond ISO standards.

iii. Establish Protocols for Specific Methods and Sub-Variants:

MRV: In addition to high-level guidelines, protocols will need to be created that are more detailed and tailored to method subvariants. The existing analogue for a MRV protocol for the 45Q tax credit is the rule for meeting measurement requirements for Subpart RR of EPA's GHGRP, which pertains specifically to the injection process. This rule outlines specific measurements that must be made and methods for calculating emissions using those measurements.

Using EPA's existing process as a model, an administering agency could create new protocols for each eligible method. To inform this process and ensure transparency, the administering agency could issue a request for information and create protocols through the rulemaking process, so the public has an opportunity to provide comment.

In some instances, there may be a need to create a protocol for subvariants of eligible methods. For this reason, it may be helpful to establish a petitioning process separate from the eligibility process for the creation of new protocols.

LCA: If ISO standards are used in conjunction with additional guidelines as described above there may not be a need for additional LCA standards if those guidelines incorporate the needs of different subvariants sufficiently.

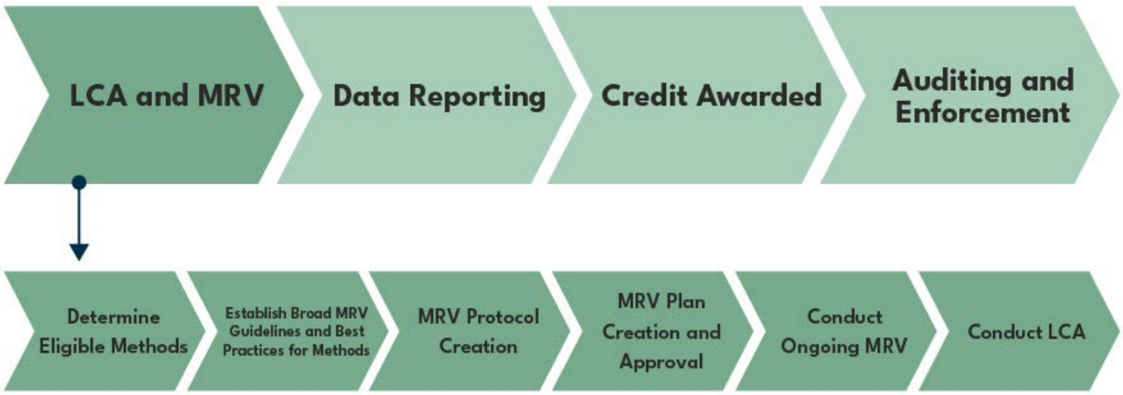
iv. **MRV Plan Creation and Approval:** The implementation of a protocol will be different for every project. For that reason, requiring the creation of MRV implementation plans at the project level can help ensure the highest level of oversight. For example, for the 45Q tax credit, a project developer must first submit a MRV implementation plan in compliance with Subpart RR of EPA's GHGRP. EPA reviews the implementation plan and provides feedback. After project developers sufficiently correct their plan to incorporate any feedback, the plan can then be approved. These approvals are valid for multiple years. A similar system could be established for the implementation of a new CDR tax credit.

v. **Conduct Ongoing MRV:** After implementation plans are finalized, a project can then proceed and conduct ongoing MRV in accordance with the approved plan. To maximize oversight in the MRV process, it may be beneficial to create a system for accrediting third parties who can verify MRV and report to the government.

vi. **Conduct LCA:** After MRV data has been collected, an LCA can then be conducted using that yielded data as an input.

These steps are summarized in the below diagram.

Figure 10: Lifecycle Analysis (LCA) and Measurement, Reporting, and Verification (MRV) Process



Note: A visual representation of the primary steps in the accountability process for a CDR tax credit as described in this paper's accountability section with a detailed representation of the steps within the LCA and MRV portion of the process.

E. Data Reporting and Awarding of Credit

It is possible that the IRS will need to work with another agency that has technical expertise to review MRV reports and LCAs. These agencies will have to coordinate to establish review process and timelines as they have done for the 45Q tax credit.

F. Auditing and Enforcement

The IRS has existing authority to audit claims for tax credits. However, the IRS does not have the expertise to evaluate MRV methodologies and LCAs. The below options summarize the various ways an auditing system could be created. These options could all possibly be used in combination.

Option 1: Normal IRS Auditing Procedure

The IRS currently selectively audits claims. Notably, the IRS, by nature, does not have significant internal expertise on MRV or LCAs. For example, the IRS relied on EPA and DOE's assessment and approval of MRV and LCAs respectively for the 45Q tax credit. For this reason, there may be a desire to go beyond the IRS's normal process.

Option 2: Additional Non-IRS Government Audits and Credit Recapture

At various points in the MRV process, the government could require an audit. Auditing processes can be helpful for ensuring quality in instances when third party entities, such as third-party verifiers, are involved in the MRV process.

Such audits could be paired with a credit recapture provision to give the audit additional teeth. Frequently, tax credits will have a recapture mechanism that is triggered if a project does not come to fruition or if otherwise fails to meet standards.

G. Administering Agency

The tax code is administered exclusively by the IRS and Treasury; however, as discussed above, the tax credit designs outlined in this paper would require IRS/Treasury to work in consultation with another expert agency or agencies.

For a CDR tax credit that more closely resembles a PTC, an agency would likely have to evaluate MRV plans, manage reporting, and track changes in project status and performance, including addressing reversals. It may also be required to manage a petition process wherein an applicant could request approval for a method or method subvariant that has neither been expressly identified by Congress in statute nor previously made available through regulation.

Option 1: Exclusive IRS Authority

One option would be to give the IRS authority over all aspects of the program. The IRS has primary administrative authority over tax benefits and its role in implementing the Inflation Reduction Act would be relevant here as well. On the other hand, the IRS lacks the content expertise to evaluate technical aspects of CDR methods, which will be especially demanding in the case of new and emerging methods.

While the IRS has primary authority over all tax incentives, another agency could assist with the administration of the credit. For example, in its initial guidance for implementation of the Section 48C tax credit for advanced energy projects, the IRS outlines a role for DOE in providing recommendations on worthy projects.[45]

Option 2: Expansion of DOE and EPA Roles

For the implementation of 45Q, IRS defers to existing MRV polices under EPA GHGRP and requires DOE to review LCAs. One option is directing both agencies to expand their role in performing both. For both agencies, this would likely be a significant expansion that would require additional funding for staffing and other expenses.

However, there are some concerns that may arise with this approach. While EPA may have the expertise to approve MRV plans for geologic injection, there may be more relevant expertise on other CDR storage methods at DOE and NOAA for other CDR methods. This could partially be addressed through consultation with other agencies.

Table 5: Potential EPA GHG Reporting Program Coverage of CDR Methods

CDR Method	Existing EPA GHG Reporting Requirement
Bioenergy with Carbon Capture and Storage	Subpart RR for injection for geological storage
Bio-Oil Injection	Subpart RR for injection for geological storage
Biochar	None
Hydrogen Production from Biomass with CCS	Subpart RR for injection for geological storage
Biomass Burial	None
Direct Air Capture	Subpart RR for injection for geological storage
Direct Ocean Capture	Subpart RR for injection for geological storage
Terrestrial Advanced Weathering	None
Ocean Based Advanced Weathering	None
Electrochemical Alkalinity Enhancement	None

See Also: A Guide to Carbon Dioxide Removal Methods for in-depth explanations of methods listed in the left-hand column.

Source: United States, Environmental Protection Agency, Code of Federal Regulations, title 74 (2009). https://www.govinfo.gov/content/pkg/CFR-2021-title40-vol23/pdf/CFR-2021-title40-vol23-part98.pdf pg. 687 -1247

Option 3: Centralization in One Entity

There may be a desire to centralize the creation of standards for LCAs/MRV and reporting process into a central entity in one agency. This could be accomplished either in statute or as an implementation choice by the IRS. However, given that there is existing precedent for splitting up these processes there may be a benefit to specifying which agency should oversee these processes. The directed agency could either house these processes in an existing office or create a new one. This office could be similar in design to EPA's GHGRP or DOE's Federal Energy Regulatory Commission (FERC) but with a focus on CDR. This option may streamline administration; however, it may also result in duplication across agencies in some instances. One option for mitigating issues that may arise because of duplication is the creation of an accompanying interagency task force.

Conclusions

To reach a net-zero emissions target and avoid the worst impacts of climate change, CDR will need to be deployed rapidly while still ensuring quality. A federal tax credit could play a major role in scaling CDR activities. There are many options for how to design a new CDR tax credit. Different choices can result in very different policies and incentive structures. Any new CDR tax credit will have to consider factors such as measurability, administrative burden, environmental impacts, and community impacts.

List of Acronyms

BECCS	Bioenergy with Carbon Capture and Storage
BiCRS	Biomass with Carbon Removal and Storage
BOEM	Bureau of Energy Management
BLM	Bureau of Land Management
CO2	Carbon Dioxide
CDR	Carbon Dioxide Removal
CCS	Carbon Capture and Storage
DOE	Department of Energy
DAC	Direct Air Capture
DOC	Direct Ocean Capture
OAE	Ocean Alkalinity Enhancement
EW	Enhanced Weathering
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program
GREET	Greenhouse Gases, Regulated Emissions and Energy Use in Transportation Model
IPCC	Intergovernmental Panel on Climate Change
ITC	Investment Tax Credit
LCA	Life Cycle Analysis
MRV	Measurement, Reporting, and Verification
NOAA	National Atmospheric and Ocean Administration
NEPA	National Environmental Protection Act
PTC	Production Tax Credit
RFS	Renewable Fuel Standard

Glossary of Terms

Afforestation	The practice of cultivating forests in areas that have not recently been forested.
Agricultural waste	Non-intentionally produced biomass that is produced from agricultural practices.
Ambient Air	A term used in the Clean Air Act and the 45Q tax credit that is defined in regulation as "That portion of the atmosphere, external to buildings, to which the general public has access".
Artificial Downwelling	A CDR method involving forcing carbon rich water into the deep ocean where the carbon is unlikely to circulate into the upper hydrosphere in the near term.
Artificial Upwelling	A CDR method involving forcing nutrient rich deep ocean water into the upper hydrosphere to stimulate biogenic activity that results in carbon sequestration.
Biochar	Biomass that is processed to create a solid char like material that is commonly used as a soil amendment.
Bioenergy with Carbon Capture and Storage (BECCS)	A BiCRS method that also results in energy creation and utilizes carbon capture technology.
Biomass Burial	A CDR method in which nutrient-poor and carbon-rich biomass such as woody biomass is buried in solid form deep underground to prevent carbon dioxide from being emitted during the decomposition process. This is also sometimes referred to as terrestrial biomass sinking.
Biomass with Carbon Removal and Storage (BiCRS)	A CDR method that utilizes biological processes to capture carbon and technological processes to extend the carbon storage duration.
Bio-Oil Injection	A form of BiCRS in which biomass is processed into an oil and then injected into geological formations to store the carbon in the biomass.
Bureau of Energy Management (BOEM)	Department of Interior agency with regulatory authority over the outer continental shelf and its resources.
Bureau of Land Management (BLM)	Department of Interior agency with regulatory authority over federal lands and their resources.

Byproducts	Products that are created because of a carbon removal process.
Carbon Capture	Capturing carbon dioxide emissions at a point source.
Carbon Dioxide (CO2)	A greenhouse gas that contains 1 carbon atom and 2 oxygen atoms.
Carbon Dioxide Removal (CDR)	The process of intentionally removing carbon dioxide from the atmosphere or hydrosphere to reduce the concentration of carbon dioxide in the atmosphere either for the purpose of drawdown or offsetting. This process is sometimes referred to as carbon removal.
Carbon Capture and Storage (CCS)	The practice of storing carbon that has been captured for long durations of time to prevent its release into the atmosphere.
CDR Project	A specific and singular CDR facility or operation.
Coastal Blue Carbon	The practice of both caring for existing coastal vegetation and cultivating new vegetation in areas where vegetation has recently decreased or has been removed entirely. This is done both to minimize the possibility of currently carbon being released and to increase carbon sequestration.
Coastal Enhanced Weathering	A CDR method in which rock is processed to make it more rapidly bond with carbon dioxide in the ambient air, removing the carbon dioxide from the atmosphere. The rock is applied to shorelines in this variation. The carbon dioxide is eventually stored in the ocean. This is also considered a version of ocean alkalinity enhancement.
Co-Benefits	Positive non carbon removal outcomes that result from a CDR project.
Credit Recapture	A provision frequently included in tax credits that stipulates that under certain conditions all or a portion of a previously claimed tax credit can be reclaimed by the federal government.
Critical Point	In the context of discussing a supercritical fluid, the point at which either pressure or temperature needs to be for a substance to be neither gaseous or liquid.
Department of Energy (DOE)	The United States federal agency charged with overseeing a variety of activities related to researching, producing, and regulating energy.
Direct Air Capture (DAC)	A CDR method in which carbon dioxide is captured from the ambient air and isolated.

Direct Ocean Capture (DOC)	A CDR method in which carbon dioxide is captured from the upper hydrosphere and geologically stored, this results in the ocean absorbing more carbon dioxide.
Drawdown	The process of removing "legacy" emissions from the atmosphere to decrease concentrations of carbon dioxide in the atmosphere compared to a baseline level before removal occurs.
Electrochemical Ocean Alkalinity Enhancement (OAE)	A CDR method in which electricity is used to cause chemical reaction that increases the alkalinity of sea water. This results in the ocean absorbing more carbon dioxide from the atmosphere.
Enhanced Weathering (EW)	A CDR method in which rock is processed to make it more rapidly form stable bonds with carbon dioxide, removing the carbon dioxide (CO_2) it bonds with from the atmosphere. This is an accelerated version of the natural rock weathering process. There are multiple variations of this CDR method that utilize various feedstocks and take place in various locations. This process is also referred to as ex-situ mineralization, enhanced rock weathering (ERW), and advanced weathering.
Environmental Protection Agency (EPA)	The United States federal agency charged with overseeing, researching and regulating a variety of activities related to environmental quality.
Forest Management	The practice of caring for existing forests to minimize the possibility of carbon stored in them being released and create conditions that maximize carbon sequestration.
Forest Management Waste	Woody biomass that is produced from practices that ensure the health and long-term sustainability of forests.
Geologic Storage	Storage of carbon dioxide that takes place in geologic formations (e.g., saline aquifers, coal seams) and/or results in the creation of geological material that stores carbon dioxide (e.g., in-situ and ex-situ mineralization).
Greenhouse Gas (GHG)	Gases that trap heat in the earth's atmosphere.
Greenhouse Gas Reporting Program (GHGRP)	An Environmental Protection Agency led program that requires certain entities to track and report greenhouse gas emissions and other related metrics.

Greenhouse Gases, Regulated Emissions and Energy Use in Transportation Model (GREET)	A tool for calculating the life cycle impacts of vehicle technologies, fuels, products, and energy systems developed and maintained by the Department of Energy's Argonne National Laboratory.
High Permanence	Methods that store carbon for a longer period of time, generally defined as storage that can be measured on the timescale of geological carbon cycle.
Hydrogen Production from Biomass with CCS	A form of BECCS that results in hydrogen production.
Injectable carbon	Carbon that is in a state where it can be safely injected underground with minimal to no risk of leakage.
Intergovernmental Panel on Climate Change (IPCC)	The United Nation's body charged with assessing the science of climate change.
Investment Tax Credit (ITC)	A tax credit that is claimed based on the upfront costs of developing a project or facility.
Legacy Emissions	Carbon Dioxide that has already been emitted into the atmosphere and is presently in the atmosphere.
Life Cycle Analysis (LCA)	A process used to measure the greenhouse gas emissions and environmental impact of a product or system of the course of its lifetime.
Low Permanence	Methods that store carbon for shorter periods of time. This often refers to CDR methods that achieve no more than 100 years of permanence, including CDR methods that store carbon on the timescale of a biological carbon cycle.
Measurability	The ability to measure removals with a high level of precision and accuracy.
Measurement, Reporting, and Verification (MRV)	The process of monitoring and measuring multiple metrics of a project to yield reportable data and verifying that data. This term is primarily used in the context of reporting data on emissions and removals. Other terms that are used to refer to the same processes are "Measuring, Monitoring, and Verification (MMRV)" and "Monitoring, Reporting, and Verification (MRV)".
Method	A group of removal methods that share the same characteristics.

Method Subvariant	A variation of a method.
Mid-Range Permanence	Methods that store carbon for longer than low-permanence methods and less than high permanence methods. This often refers to CDR methods that achieve greater than 100 years of carbon dioxide storage but less than 1000 years of carbon dioxide storage. It can also refer to methods that Achieve storage longer than an average biological carbo cycle but shorter than a geologic carbon cycle.
National Atmospheric and Ocean Administration (NOAA)	A United States federal agency within the Department of Commerce that is charged with monitoring and researching matters related to the ocean and atmosphere.
National Environmental Protection Act (NEPA)	A federal environmental quality law that requires federal agencies to consider environmental impacts in federal actions that could pose a significant impact to the environment.
Nature Based Solutions (NBS)	CDR methods that rely on replicating or managing existing biological processes that reduce carbon dioxide in the atmosphere. This term does not include processes that rely on existing biological processes to sequester carbon but then extend the sequestration period by processing and/or utilizing the biological material.
Net-Negative	A system, process, or product that removes more carbon than it emits.
Net-Neutral	See Net-Zero.
Net-Zero	A system, process, or product that emits no overall carbon. This can occur when removals are equal to emissions or when emissions are zero.
Ocean Alkalinity Enhancement	A form of CDR in which alkalinity is introduced into the ocean to trigger an exchange that results in the ocean absorbing additional carbon dioxide (CO_2).
Ocean Fertilization	The process of adding materials, such as iron, to the upper hydrosphere to stimulate biogenic activity that results in carbon sequestration.
Ocean-Based Enhanced Weathering	A form of CDR in which rock is processed to make it more rapidly bond with carbon dioxide in the ambient air, removing the CO_2 from the atmosphere. The rock is directly deposited in the ocean, where it can be stored, in this variation. This is also considered a version of ocean alkalinity enhancement.

Offset	A removal that occurs to neutralize a concurrent or recent emission. Offsets achieve carbon neutrality but are not net negative. Verb form is offsetting.
Overshoot	The state of exceeding the global warming targets established in the Paris Accord.
Pathways	Specific forms of fuel and processes for creating fuels that have been approved under the Renewable Fuel Standard.
Permanence	The ability of a removal method to achieve long-term storage of carbon dioxide removal.
Point Source	A concentrated source of emissions with clearly definable boundaries. An example is a power plant that emits CO2.
Production Tax Credit (PTC	A tax credit that is claimed based on a quantity of an output that is created by a project or facility.
Protocol	Specific guidelines for how to conduct MRV for a CDR method or method sub-variant.
Reforestation	The practice of cultivating forests in areas that have recently been forested but have since experienced deforestation.
Removal	Withdrawal of carbon from the atmosphere by a CDR method.
Renewable Fuel Standard (RFS)	A program managed by the Environmental Protection Agency that requires transportation fuel in the United States to contain a minimum percentage of fuels derived from renewable biomass.
Reversal	When carbon that has been removed from the atmosphere reenters the atmosphere.
Seaweed Cultivation	Practices that involve cultivating macro algae to sequester carbon in the macro algae.
Seaweed Sinking	The process of submerging macro algae and in effect the carbon stored in macro algae in portions of the ocean deep enough that the carbon will not circulate into the upper hydrosphere in the near term.
Secure Geological Storage	Any form of geological storage that has an extremely low risk of reversibility under certain conditions.
Sequestration	The act of storing carbon that was previously in the atmosphere.

Soil Management	Various practices that minimize the possibility of carbon stored within soils to be released.
Storage	The act of sequestering carbon that was previously in the atmosphere.
Storage Duration	The period of time that carbon is stored.
Supercritical Fluid	A substance that is at a state in which its temperature and pressure are at or exceed a point known as its critical point (i.e., not distinctively gaseous or liquid), but is distinctively in a state in which it is not solid.
Supercritical Carbon Dioxide	Carbon Dioxide in supercritical fluid state. In this state, the carbon dioxide can be injected underground or utilized as a pure carbon dioxide stream.
Technological Readiness	The degree to with a technology is ready to be commercialized. High technology readiness indicates that a technology is closer to a state of being commercially deployable. Technologies can be assigned technological readiness levels (TRL) that correspond to differ parts of the research, development, and deployment process.
Technology Neutral	An approach to development that is inclusive of all technologies that achieve the same ends.
Terrestrial Enhanced Weathering	A form of enhanced weathering. In this variation, rock is applied to fields as a soil amendment and eventually makes its way into waterways and then into the ocean where it is stored on a geological time scale.
Voluntary Carbon Market	A market where entities that are not required to do so under law can purchase carbon dioxide emissions offsets and removals.

ENDNOTES

1 This white paper does not necessarily represent the views of Van Ness Feldman, LLP, or its clients.

2 Energy Futures Initiative, CO2-Secure: A National Program to Deploy Carbon Removal at Gigaton Scale, p. 8, Dec. 2022. (Summarizing recent IPCC report noting that every "illustrative mitigation pathway" required "significant levels of CDR deployment globally" and noting need for gigaton scale reduction in carbon dioxide per year) (hereinafter, "CO2-Secure"); see also Intergovernmental Panel on Climate Change (IPCC), Climate Change 2022: Mitigation of Climate Change.

3 CDR is different from "carbon capture," which is a term generally used to describe activities involving the capture of CO2 emissions from a particular point source, such as a power plant or industrial facility. Carbon capture projects reduce or eliminate emissions from the relevant point source(s) but do not achieve a net removal of total CO2 from the atmosphere.

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