Carbon Direct

Navigating Carbon Credit Registries

Differences, risks, and guidance

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Contents

Acronyms and abbreviations

ACR: American Carbon Registry
ARR: afforestation, reforestation and revegetation
BiCRS: biomass carbon removal and storage
CAR: Climate Action Reserve
CCP: Core Carbon Principles (Integrity Council for the Voluntary Carbon Market)
CDR: carbon dioxide removal
ERW: enhanced rock weathering
GS: Gold Standard
ICVCM: Integrity Council for the Voluntary Carbon Market
IFM: improved forest management
mCDR: marine carbon dioxide removal
MRV: monitoring, reporting, and verification
MMRV: measurement, monitoring, reporting, and verification
VCM: voluntary carbon market
VCS: Verified Carbon Standard
VVB: validation and verification body
WFE: World Federation of Exchanges

Executive summary

Buyers today face a complex landscape when navigating registries in the voluntary carbon market (VCM). These registries employ various approaches to issuing and managing seemingly similar carbon credits, even for credits from the same project type or carbon dioxide removal (CDR) pathway. While they offer comparable mission statements around ensuring credible carbon credits, each registry differs in their underlying methodologies[1] and protocols,[2] business models, fee structures, risk assessments, covered project types, and operations. These differences can result in significant impacts to credit cost, quality, risk, and performance, making procurement a complex endeavor.

Case studies across different CDR pathways reveal stark differences between registries. For example, comparable biochar projects will differ in the number of credits issued, promised storage duration, and have radically different costs based on the registry. Registries also treat emerging pathways like enhanced rock weathering (ERW) differently.

Credit outcomes vary for the same project type. Methodologies and protocols for the same project types differ across registries, with varying data requirements, assumptions, and tolerance levels for scientific uncertainty.

Registries vary in when they charge fees and who they charge them to. Some registries require upfront payment before CDR occurs ("ex ante" payment) and, at times, before a project begins construction or operation. Other registries charge upon or after credit issuance or delivery ("ex post" payment). Some registries charge project developers (suppliers) for validation and issuance, while others charge buyers.

Registries deliver differing levels of customer service and value that goes beyond the basic methodology. The timeframe for credit issuance differs significantly between registries. Established registries often have lengthy approval and verification processes, causing backlogs that can delay credit availability. While established registries are working to accelerate their processes, newer more digitally oriented registries promise faster verification and issuance.

Registries do not guarantee project success, particularly for ex ante purchases. Buyers entering into forward purchase agreements should understand that a registry, even in idealized circumstances, cannot guarantee the successful delivery of a tonne of CDR from a specific project. Buyers should carefully evaluate registry claims of providing project assurance. Buyers should also be mindful when registries simultaneously draft methodologies and closely partner with suppliers subject to that methodology. Forward purchases are important for the carbon market and can provide critical support for early-stage projects; but no registry can guarantee a project's success or eliminate all risks.

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[1] Methodologies establish consistent, transparent rules for measuring, monitoring, reporting, verifying, and certifying CDR activities. They align with the principles and criteria of their associated standards.
[2] Protocols define specific adaptations or subsets of existing methodologies. Though often synonymous with methodologies, a protocol can offer more detail or adapt an existing standard. Registry terminology varies, and the two terms frequently overlap.

The carbon credit registry landscape

Carbon credit registries serve critical functions within the voluntary carbon market. An effective registry sets robust methodologies and protocols, tracks life-cycle emissions, issues and provides a ledger for a large number of credits, requires monitoring, and maintains buffer pools, among other services. Carbon credit buyers generally require a registry to verify CDR claims. While all major registries state a similar mission of ensuring high-quality standards in the VCM, registries vary dramatically in cost, timing of fees, and the methodological treatment of different CDR pathways. Buyers should take a pragmatic view on the important, but limited, role a registry should play in informing their purchasing decision.

Years of public challenges to popular carbon credit methodologies and protocols [3, 4] and their reported shortcomings [5, 6] have prompted emerging start-ups and industry initiatives to work toward improving trust in the VCM. The Integrity Council for the Voluntary Carbon Market (ICVCM) serves as an umbrella organization, assessing methodologies and protocols with the goal of systematically improving quality across the VCM.[7, 8]

Despite these emerging efforts, buyers today still encounter a complicated landscape. Seven registries accounted for approximately 90% of total retirements in 2024: American Carbon Registry (ACR), Climate Action Reserve (CAR), C-Sink, Gold Standard (GS), Isometric, Puro.earth, and Verra (VCS).[9, 10] These registries have differences in the methodologies and protocols they offer and which CDR pathways they cover (**table 1**). They also differ in processes and fee models, which can impact both the total cost of CDR credits and their associated risks.

[3] Haya BK, Evans S, Brown L, Bukoski J, Butsic V, Cabiyo B, Jacobson R, Kerr A, Potts M, Sanchez DL. 2023. Comprehensive review of carbon quantification by improved forest management offset protocols. Front For Glob Change. 6. [accessed 2025 Jun 26]. https://doi.org/10.3389/ffgc.2023.958879.
[4] Dupla X, Bonvin E, Deluz C, Lugassy L, Verrecchia E, Baveye PC, Grand S, Boivin P. 2024. Are soil carbon credits empty promises? Shortcomings of current soil carbon quantification methodologies and improvement avenues. Soil Use and Management. 40(3):e13092. https://doi.org/10.1111/sum.13092.
[5] Carbon Market Watch. 2024. Lost in Documentation: Transparency in voluntary carbon market registries. [accessed 2025 Jun 26]. https://carbonmarketwatch.org/wp-content/uploads/2024/04/CMW-Lost-in-Documentation-Transparency-in-voluntary-carbon-market-registries.pdf#:~:text=VCS%20207%207%207%203.4,3.3.
[6] Greenfield P. 2023 Jan 18. Revealed: more than 90% of rainforest carbon offsets by the biggest certifier are worthless, analysis shows. The Guardian. [accessed 2025 Jun 26]. https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe.
[7] This assessment evaluates registries and credit types against the ICVCM's set of Core Carbon Principles (CCPs). Once designated CCP-compliant, registries are able to apply a CCP-label status to eligible credits.
[8] The Integrity Council for the Voluntary Carbon Market. c2025. The Assessment Framework. [accessed 2025 Jun 26]. https://icvcm.org/assessment-framework/.
[9] This is based on retirement data from ACR, ART Trees, BioCarbon Standard, CAR, Climate Forward, EcoRegistry, Global Carbon Council, C-Sink , GS, Isometric, Plan Vivo, Puro.earth, and VCS, with analysis conducted by Carbon Direct.
[10] Saunders J, Akhouri U, Turner G, Lambert J. 2025 Jan 6. Frozen Carbon Credit Market May Thaw as 2030 Gets Closer | MSCI. [accessed 2025 Jun 26]. https://www.msci.com/research-and-insights/blog-post/frozen-carbon-credit-market-may-thaw-as-2030-gets-closer.

Table 1. Availability of CDR methodologies and protocols by registry

CDR pathway	Registry						
	ACR	CAR	C-Sink	GS	Isometric	Puro.earth	VCS
ARR							
Biochar				In development			
Biomass burial							
DAC	In development			In development			
ERW							On hold
Geologic BiCRS	In development						
IFM							
mCDR						In development	
Mineralization							

Note: Dark green = methodology or protocol offered, light green = in development or on hold, gray = not offered. ARR = afforestation, reforestation, and revegetation, DAC = direct air capture, ERW = enhanced rock weathering, BiCRS = biomass carbon removal and storage, IFM = improved forest management, mCDR = marine CDR. Pathway coverage is not universal and may be limited to certain activity types within credit categories (e.g., concrete mineralization). For instance, marine CDR does not include tidal and wetland restoration. Data collected from registry websites and may not be inclusive of all in-development methodologies or protocols.

Most registries follow a financial model that splits fees into two types: (1) fees charged on a per-account (e.g., annual maintenance) or per-project (e.g., project submission) basis, and (2) fees charged on a per-credit basis (e.g., issuance). All major registries, except for Isometric, charge the developer the issuance fees. The developer also generally compensates accredited third-party validation and verification bodies (VVBs) to certify that the project conforms to the chosen registry's methodology or protocol requirements. Isometric charges buyers a per-tonne fee and pays for VVB fees for projects in the Isometric standard. Whether they are compensated by the registry or some other party, verifiers are required to hold independent third-party accreditation.

While registries may market their fee structures differently, and some have made attempts to separate fees from credit volumes, all registries calculate fees by multiplying the volume of credits (issued or approved) by the fee per credit. Carbon credit buyers should critically interrogate any registry's marketed claims that fees are disassociated from volume.

To illustrate how fees can vary for the same project and credit type across registries, **table 2** compares all-in costs for a biochar project across different registries. The table shows costs for 10,000 annual CDR credits issuing from a single project site for five years, for a total of 50,000 credits. Costs include account opening, account maintenance, project submission, project review, registry validation and verification review, issuance, and retirement fees. The values for percentage of fees charged before CDR occurs are based on the sum of fees charged related to account opening, account maintenance, project submission, project review, registry validation, and verification review fees/total cost. ACR does not offer a biochar methodology, but charges the same fees for all offered pathways. GS's biochar methodology is in development, and the values given here assume this methodology will use the same price schedule GS uses for all other projects. Puro.earth values assume a 5% issuance payment discount, per Puro.earth's fee schedule. Isometric has not recently published information on payment timelines for buyers. The most recent information, from their 2023 ICROA application, cited up-front payment for orders under $25,000. As a result, 100% of Isometric fees on offtakes under this threshold would be charged prior to CDR. For high-value or longer-duration offtakes, such as in this example, the Isometric fee schedule may be payable both before and during project activities.[11]

Table 2. All-in costs by registry for first 50,000 credits of a biochar project, *US$*

Registry	ACR	CAR	C-Sink	GS	Isometric	Puro.earth	VCS
Total cost	$14,500	$12,500	$164,118	$24,000	$500,000	$441,324	$24,750
Share of fees charged before CDR occurs	24%	24%	1%	44%	Variable, including fees payable before and during removal period	2%	50%

Note: These numbers are accurate as of June 27, 2025.

The timing of fees is also a key differentiator between registries. ACR, CAR, C-Sink, GS, Puro.earth, and VCS charge the majority of fees at the time of issuance or retirement (this is often referred to as "ex post," or occurring only after the removal has taken place). Prior to the issuance of credits, these registries also charge for account fees related to account opening and maintenance, and project fees related to listing the project on the registry.

[11] Isometric. 2024. Assessment Framework, v1.0. [accessed 2025 Jun 26]. https://icroa.org/wp-content/uploads/2024/10/Isometric-Application-Report_-ICROA.pdf#:~:text=Revenue%20Structure%3A%20Isometric%20charges%20buyers,tonne.

Today, only a small fraction of high-durability CDR projects on registries like C-Sink, Isometric, and Puro.earth are at the stage of issuing tonnes. While forward purchasing of high-durability CDR is critical to enable the market to scale, these projects are also inherently risky. It is likely that some prepaid credits will not be issued if projects underperform, are delayed, or are cancelled. The success of high-durability CDR projects is dependent on suppliers scaling first-of-a-kind projects, securing finance, and establishing the engineering capacity to scale facilities. Some buyers have already purchased credits from CDR facilities that will never be built.[12] Registries often use credits from a buffer pool to compensate for that loss, but it is impossible in most circumstances to compensate the buyer on a strictly like-for-like basis. Buyers should consider the risk of project non-delivery and associated recourse mechanisms before tying up capital in forward purchases and before compensating a registry.

Differences between the carbon credit registries go beyond costs and types of projects covered. Registries differ in their customer service and speed of credit issuance, with some registries offering a more tech-forward and potentially expedited customer experience. The time it takes for a project to move through the registry pipeline—from methodology or protocol approval and project validation to credit issuance—varies between registries and is an important factor for developers and buyers to consider. The World Federation of Exchanges (WFE) recently analyzed the VCM and found that the average issuance lag, defined as the weighted average time between vintage year and issuance, is 2.45 years. The WFE concluded that the VCM is over 10 times less efficient in bringing products to market than comparable financial instruments, such as Green Bonds (8-12 weeks). The WFE also noted that lengthy monitoring and verification cycles may result in higher costs to suppliers, limited access to capital, and broadly disincentivized market participation.[13] To the extent that innovation can offer more streamlined processes and an improved customer experience, speed to market offers a compelling value proposition for buyers to consider and pay for, provided the registry maintains rigor in the process.

Case study: Methodological differences affect biochar credit protocols

Biochar, a charcoal-like carbon material produced by pyrolysis of biomass and commonly applied to soil, is one of the most widely adopted forms of biomass carbon removal and storage (BiCRS), a form of hybrid CDR.[14] Because of its growing popularity and relatively accessible technology, there are several registries with methodologies and protocols to certify biochar-based CDR.[15, 16] Biochar provides an excellent case study to compare how different registries handle the same type of project. Six of the seven major registries either have an approved biochar methodology or protocol,

[12] Examples include: (1) The Next 150's scrapped a first-of-a-kind biochar facility which had contracted nearly 120,000 tonnes of undelivered offtake, and (2) Running Tide's biomass sinking project, which ceased operations despite over 10,000 tonnes of unfulfilled or partially fulfilled orders (data provided by CDR.FYI under commercial license).
[13] Liu Y, Gurrola-Pérez P. The dynamics of voluntary carbon markets: An empirical analysis of the carbon credits lifecycle. World Federation of Exchanges. [accessed 2025 Jun 10]. https://www.world-exchanges.org/our-work/articles/dynamics-voluntary-carbon-markets-empirical-analysis-carbon-credits-lifecycle
[14] Hybrid CDR pathways refer to those that are driven by abiotic chemical reactions in the terrestrial biosphere or ocean (e.g., ERW) and/or those that utilize harvested biomass (e.g., BiCRS), exclusive of traditional nature-based solutions (e.g., IFM, ARR).
[15] From 2022 to 2024, the global biochar market has grown from nearly 70,000 tonnes to 870,000 tonnes. This growth is accelerating. In 2025, through May 18th, approximately 1,800,000 tonnes of biochar have been transacted, per CDR.FYI data.
[16] CDR.fyi. [accessed 2025 Jun 26]. https://www.cdr.fyi/.

or are in the process of developing one. While only C-Sink and Puro.earth have issued biochar credits, the release of new methodologies and protocols is leading biochar suppliers to diversify their registry selections.[17] Critically, methodologies and protocols from different registries provide distinct approaches to quantifying carbon permanence and crediting (**table 3**).

Table 3. Summary of methodology and protocol approaches to quantifying biochar permanence

Methodology/protocol	Approach	Data requirements	Durability claim
CAR (U.S. and Canada Biochar Protocol, Version 1.0)	Woolf et al. (2021)	• H/C_{org} • Dry matter % • Organic Carbon %	100 years
European Biochar Certificate (Global Biochar C-Sink Standard, v3.1)	Schmidt et al. (2022)[18]	• H/C_{org} • Organic Carbon %	Flexible timeframe
Isometric (Biochar Storage in Agricultural Soils, v1.1)	• Option 1: Woolf et al. (2021) • Option 2: Sanei et al. (2024)[19]	• Soil temperature (Option 1) • H/C_{org} (Option 1) • Random reflectance of biochar (Option 2)	200 years (Option 1) 1,000 years (Option 2)
Puro.earth (Biochar Methodology, Edition 2022 V3)	Woolf et al. (2021) model[20]	• H/C_{org} • Soil temperature	100 years
VCS (VM0044 Methodology for Biochar Utilization in Soil and Non-soil Applications, Version 1.2)	IPCC, 2019[21] and Woolf et al. (2021)	• Organic carbon content • Production temperature or production process	100 years

Note: H/C_{org} refers to the ratio of hydrogen to organic carbon in the biochar and is an indicator of how stable the material is. Random reflectance is an optical measurement used to assess the presence of highly stable forms of carbon in the biochar.

[17] C-Sink's total issuance is 345,000 tonnes of biochar credits from 48 project developers. Puro.earth's total issuance is 408,000 tonnes of biochar credits from 45 project developers. Registries with biochar projects pre-issuance include CAR (one developer), GS (one developer), Isometric (five developers), and VCS (seven developers).
[18] Schmidt HP, Abiven S, Hagemann N, zu Drewer JM. 2022. Permanence of soil applied biochar. The Biochar Journal. [accessed 2025 Jun 27]. http://ww.biochar-journal.org/en/ct/109.
[19] Sanei H, Rudra A, Przyswitt ZMM, Kousted S, Sindlev MB, Zheng X, Nielsen SB, Petersen HI. 2024. Assessing biochar's permanence: An inertinite benchmark. International Journal of Coal Geology. 281:104409. https://doi.org/10.1016/j.coal.2023.104409.
[20] Woolf D, Lehmann J, Ogle S, Kishimoto-Mo AW, McConkey B, Baldock J. 2021. Greenhouse Gas Inventory Model for Biochar Additions to Soil. Environ Sci Technol. 55(21):14795–14805. https://doi.org/10.1021/acs.est.1c02425.
[21] Intergovernmental Panel on Climate Change. 2019. Appendix 4. In: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. [accessed 2025 Jun 27]. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Ap4_Biochar.pdf.

As **table 3** shows, each registry's biochar methodology or protocol uses different scientific inputs to develop their approach, which leads to markedly different durability claims. For example, CAR, Isometric, Puro.earth, and VCS incorporate the decay model from Woolf et al. (2021), which estimates biochar carbon stability based on the H/C_{org} and the soil temperature at the site where biochar is applied. Uniquely, Isometric also offers a second option, based on Sanei et al. (2024). This model introduces random reflectance measures to identify a fraction of biochar carbon that, proponents argue, could be essentially permanent—based on a coal analogy.

In addition to these differing models for carbon loss and retention, the credited duration of carbon storage also varies. CAR, Puro.earth, and VCS each state that the biochar carbon they credit will last 100 years in soil. The European Biochar Certificate's (Global Biochar C-Sink) program does not fix a single timeframe. It certifies CDR but leaves the duration open or flexible over a range of up to 100 years.[22] Isometric credits a significantly longer durability term for biochar. Under its primary methodology, it credits 200 years of storage, and under the alternate method (if a project provides the required reflectance data showing very stable carbon), it will credit up to 1,000 years.

In other words, for the same physical volume of biochar, one registry might issue credits representing 100 years of carbon sequestration, whereas another registry could issue credits that represent 200 or even 1,000 years of storage—with different permanence fractions over a given time frame, based on differences in permanence models.

Buyers utilizing registries with a less conservative standard, particularly when paying fees up front, are taking on a higher risk because, over time, improved scientific understanding may very well identify that excessive credits have been issued. Buyers should acknowledge that the durability claims offered by their chosen registry may differ significantly from scientific consensus.

> Carbon Direct advocates for a conservative approach to biochar permanence that acknowledges evolving science and current uncertainties. Methods like the random reflectance method have not yet been sufficiently validated to be considered conservative. As research progresses, Carbon Direct strongly cautions against overstating biochar's durability until key uncertainties are better understood.

Case study: Quantification differences generate uneven soil carbon credit volumes

Soil carbon credits are generated through the adoption of regenerative agriculture practices—a holistic approach to farming that aims to improve soil health, enhance ecosystem biodiversity, and increase resilience to climate change. Practices such as no-till farming, cover cropping, crop rotation, and integrated livestock management can significantly increase the amount of organic carbon stored in the soil.

[22] Schmidt HP, Kammann C, Hagemann N. 2021. Section 2.1. In: Guidelines for the Certification of Biochar-Based Carbon Sinks, version 2.1. [accessed 2025 Jul 17]. https://www.european-biochar.org/media/doc/2/c_en_sink-value_2-1.pdf..

Over a dozen methodologies exist to generate soil carbon credits, with wide variation in how they approach key concerns like additionality, quantification and durability.[23] A recent pre-print by Kuebbing et al. (2025), examines the burgeoning voluntary markets for agricultural carbon credits.[24] The study highlights a critical issue: the lack of equivalency in carbon credit quantification across different registry methodologies, which could undermine their effectiveness in actual climate change mitigation. To test this equivalency, the researchers conducted a methodology intercomparison project. They used a common dataset from 4,988 corn-soybean fields in the US Midwest, representing a typical soil carbon project. They then estimated the number of carbon credits that would be issued for adopting no-till farming and cover cropping practices, according to three major methodologies used for US croplands.

The findings revealed significant discrepancies. For the same hypothetical project covering a 405,645 hectare area of midwestern US farmland, the number of credits issued could differ by as much as approximately 130,000 credits per year depending on the methodology used, or a highest issuance that is approximately three times higher than the lowest issuance. Updated versions of those same methodologies brought the credit issuances into closer alignment, but it is noteworthy that the shift in crediting was toward alignment in a less conservative direction. This stark variation underscores how differing assumptions embedded in the methodologies lead to markedly different crediting outcomes, as well as how outliers can influence other methodologies toward less conservative crediting standards.[25]

For a credit buyer, the key takeaway from this study is the critical need for diligence beyond simply purchasing credits from a recognized registry. The research demonstrates that the same on-the-ground, climate-friendly farming practices can result in vastly different numbers of carbon credits depending on the specific methodology used for quantification. Without this deeper understanding of how registries operate, buyers risk investing in credits that may not deliver the environmental benefits they expect, potentially impacting their sustainability claims and overall climate mitigation strategy.

Emerging CDR pathways: Ocean alkalinity enhancement and ERW

New methodologies and protocols play a critical role in setting clear and credible standards within emerging sectors. As new CDR pathways enter the field, these methodologies and protocols enable early-stage technologies to enter markets by providing a framework for monitoring, reporting, and verification (MRV). This unlocks access to funding mechanisms such as carbon credits, grants, and private investment. For CDR to scale to the magnitude required to achieve climate goals, emerging CDR pathways will need to thrive.

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[23] Oldfield EE, Eagle AJ, Rubin RL, Rudek J, SandermanJ, Gordon DR. 2021. Agricultural soil carbon credits: Making sense of protocols for carbon sequestration and net greenhouse gas removals. Environmental Defense Fund, Woodwell Climate Research Center. https://www.edf.org/sites/default/files/content/agricultural-soil-carbon-credits-protocol-synthesis.pdf.
[24] Kuebbing S, Eash L, Bradford M, Oldfield E, Ogle S. 2025. Non-equivalent carbon crediting across agricultural land management protocols. Research Square. [accessed 2025 Jun 13]. https://www.researchsquare.com/article/rs-6179173/v1.
[25] Kuebbing et al., Non-equivalent carbon crediting.

Buyers should be aware that in certain early-stage technology sectors, developing robust methodologies and protocols is particularly complex and challenging. In particular, mCDR pathways like ocean alkalinity enhancement methods face an inherent interdependency challenge, where multiple priorities must be advanced simultaneously. Critically, data from field trials and pilot-scale testing is required to develop and validate carbon MRV and environmental monitoring, reporting, and verification methodologies, assess potential ecological risks, and demonstrate environmental integrity. However, such testing cannot proceed at a meaningful scale without these very data. This situation creates a foundational paradox: evidence from early-stage deployments is necessary to build robust methodologies and protocols, while rigorous methodologies and protocols are needed to guide early deployment. Unlocking deployments and building the investor confidence, social license, and regulatory certainty needed to proceed requires these methodologies and protocols to verify performance and impact data. Without that support, projects have struggled to move beyond the conceptual or lab phase, failing to generate the very data required to justify their scale.

Some registries are rapidly developing methodologies and protocols that rely heavily on key data from a limited pool of projects and developers. Project developers' engagement in designing and publishing these methodologies and protocols presents both risks and opportunities. In the case of mCDR, the small pool of project developers has primarily shaped methodologies and protocols through their limited input and feedback. This concentration of input raises the risk of introducing bias into methodologies and protocols, which may undermine scientific rigor, reduce stakeholder confidence, and lead to the issuance of carbon credits that do not accurately reflect real-world performance. While robust methodologies and protocols have the potential to legitimize emerging approaches and support technological advancement, developing them rapidly with limited data may lead to incomplete scientific foundations for key claims such as tonnage and durability.

A methodology or protocol reflects scientific understanding from a specific point in time. Emerging research may require updates to incorporate new insights into an existing methodology or protocol, and ensure it remains accurate, relevant, and aligned with the latest understanding. As a result, methodologies and protocols may become outdated and misaligned with current best practices, leading to the issuance of credits based on incomplete or obsolete assumptions.

Case study: A comparison of ERW methodologies

Some registries have greater coverage of emerging CDR techniques and an appetite to incorporate new CDR pathways into their systems. Each registry’s process for methodology or protocol development also varies. This process generally includes internal initial drafting followed by external expert consultation and public comment periods. However, registries diverge in the extent of their reliance on external parties versus in-house science teams.[26] The outcome of these processes can result in methodologies or protocols with vastly different durability claims and total credits transacted. This variation is evident when comparing Isometric’s ERW protocol and Puro.earth’s ERW methodology.

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[26] Examples of divergence include: (1) initiating new protocol development (e.g., VCS charges external parties up to $15,000 for new protocol development, whereas Puro.earth limits new protocol initiation to staff and governing body members), and (2) final protocol approval (e.g., Isometric protocols are approved by in-house science staff, whereas Puro.earth protocols are approved by an advisory body composed of independent third party members).

ERW is a process that speeds up the Earth's natural method of removing carbon from the atmosphere by grinding specific types of rocks into fine powders and broadcasting over farmland. There, they dissolve and drawdown atmospheric carbon dioxide in the form of aqueous bicarbonate ions, which eventually wash away into ground water systems before ending up in the ocean. Established technologies like mining, grinding, and agricultural spreading make ERW a highly permanent form of CDR with a high potential to scale. Where ERW may be able to provide highly durable, scalable CDR, the technology is still nascent, and there are multiple avenues that require further research. These include quantifying carbon losses in off-site estuary and marine environments, monitoring soils to protect against heavy metal dissolution, and measurement, monitoring, reporting, and verification (MMRV) challenges. Quantifying the exact amount of CDR in the field is complicated due to the fact that carbon can be difficult to directly measure and attribute to ERW at the point of drawdown or throughout hydrological systems.

Although Isometric's protocol and Puro.earth's methodology for ERW differ, they both recognize the long-term nature of carbon storage through this mechanism, emphasizing a durability of at least 1,000 years. Despite MMRV challenges, both Isometric and Puro.earth require the inclusion of direct measurement of variables that can be correlated to drawdown in MMRV plans, although they differ on the type and course of inclusion. In addition, both registries recognize the need to quantify co-benefits from ERW, such as improvements in soil quality and agricultural yield. Developers must also monitor and safeguard against the potential risk of heavy metal dissolution.

However, the two registries' approaches to MMRV design, validation, and credit quantification differ significantly. Isometric provides strict requirements for quantification and validation, including two defined methods (i.e., soil- or water-based), separate validation procedures, statistical thresholds (i.e., 99.7% confidence), and the use of ISO/EPA standard analytical methods. In contrast, Puro.earth outlines a more flexible simulation-based approach, which is constrained by empirical data and focuses on general measurement signals like alkalinity and pH, without prescribing a distinct validation process or detailed statistical framework. For project design, Isometric defines specific sampling densities and multi-plot layouts, while Puro.earth does not require particular spatial structures or area allocations. Puro.earth gradually issues credits as a project's carbon removals are empirically validated over time, acknowledging delays in detecting and referencing specific established geochemical models for carbon drawdown via ERW. Isometric issues credits "once a statistically significant amount of feedstock weathering has occurred" and defines "reporting periods" as linked to sampling events.[27]

Implications and guidance for carbon credit buyers

Carbon registries play a critical role in the VCM ecosystem. They need to continually innovate and mature to grow the VCM. Buyers need trustworthy methodologies and protocols, and streamlined recordkeeping of their purchases. Registry improvements are critical to enabling a successful carbon market. As the VCM matures, buyers should be aware of how registry services vary across credit types.

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[27] Isometric. c2025. Enhanced Weathering in Agriculture. [accessed 2025 Jun 27]. https://registry.isometric.com/protocol/enhanced-weathering-agriculture/1.1/ctn_1JBF3A2JY1S0Z7MA.

Even the most reputable registry or rigorous methodology or protocol cannot guarantee delivery of specific forward-purchased credits. While some registries may evaluate basic aspects or elements related to potential project success, given the technological complexity, scale, and timeline of many CDR projects, assuring project delivery on contracted timelines requires ongoing monitoring and engagement with project proponents to actively mitigate risks. Registries, by their nature, are not set up to provide these services; rather, they provide components of credit quality analyses.[28] Fully assessing project execution risks involves an analysis of the project operator as a counterparty and developer; an analysis of the geographic, policy, technical, commercial, infrastructure, and economic variables that could drive success or failure; and an analysis of the project's ability to secure needed financing.

Carbon credit registries may offer comparable mission statements, but they are not interchangeable—their differences have real consequences for credit cost, quality, risk, and performance. Buyers should carefully consider the timing of payment for credits, the rigor of the underlying registry methodology or protocol, and differing claims around durability. This is true across CDR pathways. Buyers should be particularly cautious when making upfront payments without project assurance, which registries do not provide.

[28] Examples include verifying that the project developer has legal rights to credit generation or performing a basic investment analysis to determine financial additionality.

About Carbon Direct

Carbon Direct Inc. helps organizations go from climate goal to climate action. We combine technology with deep expertise in climate science, policy, and carbon markets to deliver carbon emission footprints, actionable reduction strategies, and high-quality carbon dioxide removal. With Carbon Direct, clients can set and equitably deliver on their climate commitments, streamline compliance, and manage risk through transparency and scientific credibility. Our expertise is trusted by global climate leaders including Microsoft, American Express, and Alaska Airlines, as well as by the World Economic Forum, which selected Carbon Direct as an Implementation Partner for the First Movers Coalition. To learn more, visit www.carbon-direct.com.

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