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Carbon Direct

The Navigator

Distilled insights to navigate rapidly evolving carbon markets | April 2025



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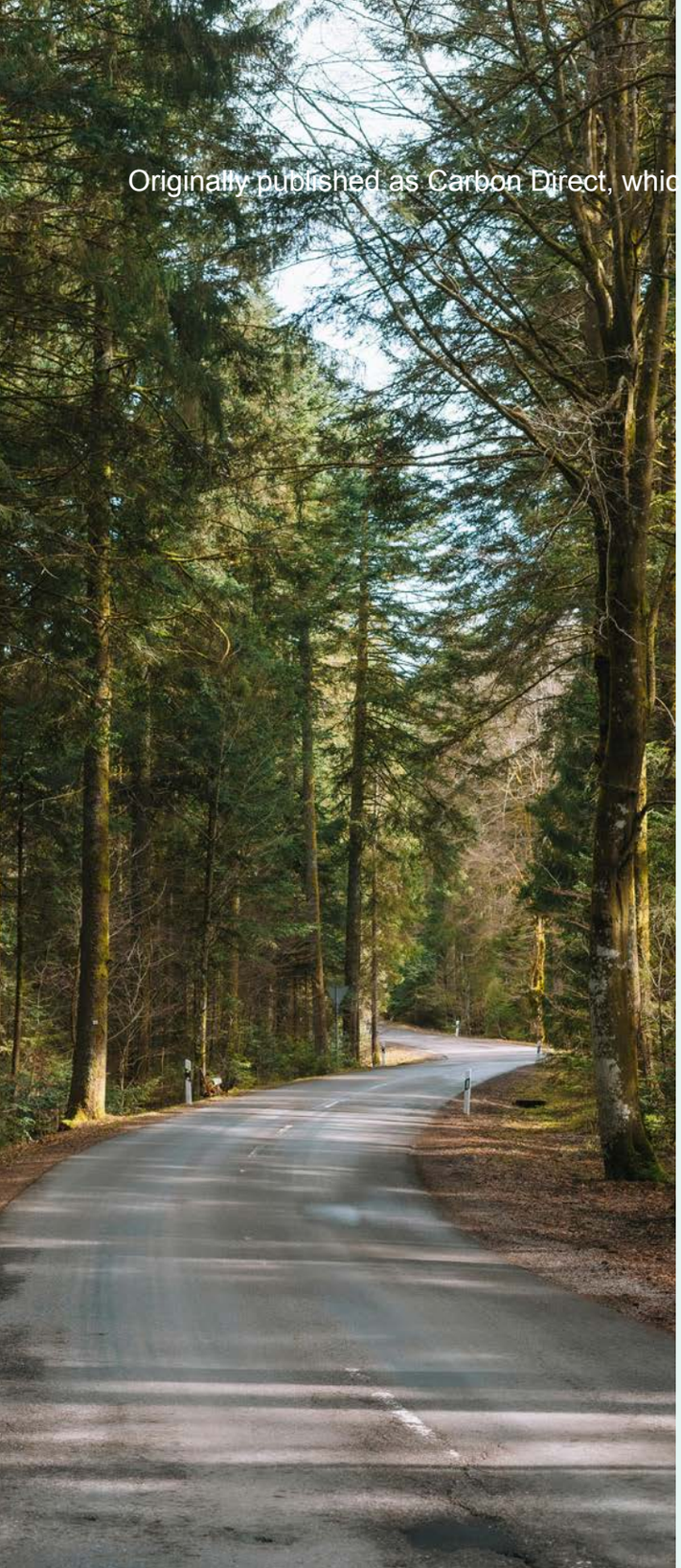
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Letter from the editor

The news comes *fast* lately. On any given day, a half-dozen digests hit my inbox, each packed with things I probably should know. It feels like a hamster wheel: the harder you try to keep up, the faster it spins. But the real world doesn't move at that pace. *The Navigator* is our attempt to step off the wheel. We took a deep breath, zoomed out, and tried to find the signal in the noise.

And the signal this quarter? US federal policy is clearly in flux—but momentum for climate action hasn't stopped. Subnational policies, voluntary markets, and global initiatives are stepping in. States like California and New York are actively advancing new bills to support carbon removal, clean construction, and climate-smart agriculture (pg. 9). Switzerland is raising the bar on climate goals (pg. 11), and Japan is about to spend US$1 trillion on decarbonization, including CDR (pg. 26).

At the same time, energy demand from the AI boom is forcing hard conversations about how to meet growing electricity needs without derailing climate targets. One underexplored path—natural gas with CCS—may be a bridge solution if deployed wisely (pg. 15). Meanwhile, marine CDR technologies are poised to scale (pg. 18). And new questions are emerging around what counts as net-zero, or what even counts as CDR (pg. 20). These are not academic sidebars—they impact how we define, buy, and scale carbon removal today.

We also look at CORSIA's growing role as a voluntary market maker (pg. 25) and offer early reflections on SBTi's draft Net-Zero Standard update (pg. 23). These market developments will shape how companies act and invest in the years ahead.

Thank you for reading this inaugural issue of *The Navigator*. Our aim is to distill the key developments shaping carbon science, policy, and markets. If there's more we can do to help you chart this rapidly changing landscape, let us know. We're here to help accelerate climate progress—no matter the headwinds.

Bodie Cabiyo, PhD
Editor and Director of Interdisciplinary Science

Acronyms and abbreviations

Carbon Direct is now Relae. Learn more at relae.co

AB: Assembly Bill
AI: Artificial intelligence
BIL: Bipartisan Infrastructure Law
BVCM: Beyond value chain mitigation
CARB: California Air Resources Board
CBAM: Carbon Border Adjustment Mechanism
CCS: Carbon capture and storage
CDR: Carbon dioxide removal
CO_2: Carbon dioxide
COP: Conference of the Parties (to the UNFCCC)
CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation
DAC: Direct air capture
DOE: Department of Energy (US)
EEUs: Eligible emissions units
EO: Executive order
EPD: Environmental Product Declaration
ERW: Enhanced rock weathering
ETS: Emissions trading system
EU-ETS: European Union Emissions Trading System
GHG: greenhouse gases
GWP: Global Warming Potential
GX-ETS: Japanese emissions trading system (within the GX-League)
GX-League: Green Transformation League
HB: House Bill
IATA: International Air Transport Association
ICAO: International Civil Aviation Organization
IIJA: Infrastructure Investment and Jobs Act
IRA: Inflation Reduction Act
J-credits: Japanese carbon credits
J-REDD: Jurisdictional REDD
mCDR: Marine carbon dioxide removal
MRV: Monitoring, reporting, and verification
NDC: nationally determined contribution
NEA: National Emergencies Act
NEPA: National Environmental Policy Act
REDD: Reducing emissions from deforestation and forest degradation
SB: Senate Bill
SBTi: Science Based Targets initiative
UN: United Nations
UNFCCC: United Nations Framework Convention on Climate Change
US: United States
VCM: Voluntary carbon market

Credits

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Given the highly collaborative nature of Carbon Direct, many people contributed insights to this report beyond the list below. The following team members contributed substantially to developing this report.

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Policy insights

POLICY INSIGHTS

Trump 2.0: Lessons from the early days

Zara Ahmed, DrPH Thaddeus Woody

When it comes to continued support at the federal level for climate-related policies, President Trump's second term is off to a rocky start. Readers may have many questions about how this will impact the fight against climate change. To answer some of the most burning questions, we are sharing a conversation between two of our experts, Thaddeus Woody (Policy Analyst) and Zara Ahmed, DrPH (Chief Operating Officer).

Thad Woody: On his first day in office, the president again withdrew the US from the Paris Agreement via executive order. What exactly does that mean and how will it impact the US's ability to collaborate with other nations on climate issues?

Zara Ahmed: This is a huge blow for global cooperation on climate, without a doubt. Withdrawing from Paris is a process that takes one year to complete—meaning that, technically, the US will still be part of the agreement as of COP30 later this year. However, the executive order stopped short of withdrawing the US from the UNFCCC and did not retract the US's NDC, which the Biden team submitted late last year.

TW: The timing of this is particularly bad, right? We have the new global climate finance target of US$1.3 trillion per year by 2035, established in Baku at COP29.

ZA: The timing is not great. Not only does this withdrawal put the climate finance goal further out of reach, it's also going to impact the ability of the world to meet broader climate goals. The US is the second-largest emitter of greenhouse gases in the world and is about to become a free rider on climate. Countries, including the US, are not on track to hit their climate targets and the goal of limiting warming to 1.5°C is slipping away. This comes at a time when leadership is most critical.

TW: A lack of engagement from the US on climate diplomacy is not the only negative development on the international stage. The Trump Administration's threat of tariffs, combined with upending trade norms, has the potential to negatively impact access to the materials needed to build out a clean economy. What actions has the Administration taken so far and what impacts might we see?

ZA: From his first day in office, we have seen the imposition of tariffs and the threat of more. We've also seen pauses or walk backs on these threats. Tariffs on imports from countries like China will cause severe supply-chain disruptions and raise costs for US energy investments, particularly for wind turbines, solar cells, and battery materials. In North America, threatened tariffs on Canada and Mexico have caused disruptions in the automotive supply chains, and will impact investment decisions around electric vehicle factories. Overall, the uncertainty created by tariffs will delay energy investments and slow the transition to low-carbon technologies.

TW: On the domestic front, the Trump Administration is attempting to freeze grant and loan funding promised by the IRA and the IIJA (or the Bipartisan Infrastructure Law). What other executive actions has the administration taken? Have any Republicans pushed back? Are all of these unilateral actions legal?

ZA: It doesn't appear that all of the funding freezes were legal and recent court decisions have restarted some payments. The administration has also removed climate and environmental justice data from official websites, including the EJScreen tool, and fired federal employees who work on environmental justice issues. Other victims of layoffs include federal employees at the DOE who are working to advance clean and sustainable

technologies through the administration of various programs mandated by the IRA and IIJA. Thad, you spent a decade on the Hill. Do you think members are going to start to balk at this?

TW: Members want projects in their state to come to fruition. For example, when a Montana-based biofuels project was tied up in the federal funding freeze, Sen. Steve Daines, the state's senior Republican Senator, was able to get the money flowing again. He worked with the White House and DOE to get funding for the project approved and out the door. This project expands a renewable biofuels plant that makes sustainable aviation fuel from agriculture products, yet the White House ultimately unlocked funding for it. Advocacy like this works.

TW: In Congress, Republican leaders in the House and Senate have started the process known as Budget Reconciliation by which they hope to enact massive tax cuts. In an effort to offset what would only be a small fraction of the cost of the IRA, they are likely to target many of its provisions, and to a lesser extent those of the IIJA, for repeal. How seriously do we take this threat to the IRA and IIJA?

ZA: First of all, it's important to note that many of the business-oriented tax credits enjoy strong bipartisan and nationwide support. For example, both the 45Q credit for carbon sequestration and the 45V credit for clean hydrogen are likely to survive, while other consumer-facing credits, such as those incentivizing electric vehicles or home energy efficiency, are more likely to meet their demise. I think the durability of certain provisions is due in large part to their support across the political spectrum, but just how deep and wide does this support go?

TW: Over 60% of the clean energy and clean vehicle projects supported by the IRA are in congressional districts represented by Republicans, including 19 of the top 20 benefiting districts. Another major driver of the staying power of these provisions is the very narrow margins held by Congressional Republicans, especially in the House where Republicans currently hold a five-vote majority. The House hasn't had a majority this slim since 1931! Last August, a group of 18 House Republicans sent a letter to Speaker Mike Johnson advocating for the preservation of clean energy tax credits from the IRA, and a similar letter signed by 21 House Republicans was sent in March. Given these small margins, and the block of Republicans who have publicly supported the IRA, it is less likely that extreme action will be taken on the clean energy provisions of the IRA.



TW: Are you seeing any bright spots or things that make you optimistic about climate action?

ZA: I think the VCM will remain resilient. The VCM remains independent of government mandates, with bipartisan support for key climate incentives like the 45Q carbon sequestration tax credit ensuring continued investment. The Trump Administration's climate retreat raises concerns, but the voluntary nature of the VCM and congressional support for key provisions will limit major disruptions.

Therefore, companies with climate commitments should consider this time as an opportunity to maximize climate impact in the midst of government rollbacks, thinking long-term and beyond the federal government. What about you?

TW: Optimism is a bit tough right now, but there are some bright spots. While certain provisions of the IRA and IIJA may be repealed, I still rate a full repeal of the IRA as highly unlikely. Though the Trump Administration may be deemphasizing climate policies at the federal level, states across the country will continue to act. States like California, Washington, and Michigan are currently considering bills related to carbon management. To use the phrase of former Justice Louis Brandeis, state-level governments will be the laboratories of democracy when it comes to climate policy.



POLICY INSIGHTS

Round up of executive orders

Thaddeus Woody

President Trump has issued several dozen executive orders since taking office in January. He has also issued multiple impactful memorandum to various federal agencies that don't technically qualify as executive orders but are important to note nonetheless. Notable actions include an executive order to withdraw the US from the Paris Climate Agreement, EPA regulatory rollbacks, and his declaration of a "national energy emergency." These actions signal a sharp pivot away from renewable energy and environmental protections, aligning with the Trump Administration's focus on fossil fuels and deregulation. As President Trump nears the end of his first 100 days, this is a good opportunity to review recent actions that will have important impacts on climate policy.

Executive order	Summary	Analysis
EO 14162: Putting America First in International Environmental Agreements	• **Withdraws the US from the Paris Agreement under the UNFCCC**	• Maintaining and enhancing global emission reduction efforts could become more challenging. • The absence of a major emitter like the **US may demotivate ambition from other countries.** • The US may become isolated from emerging clean energy and green technology markets, potentially diminishing its global negotiating power.
EO 14156: Declaring a National Energy Emergency	• **Invokes authorities under the NEA to declare an energy emergency.** • Orders departments and agencies to identify and exercise authorities to facilitate the production of domestic energy resources, including on federal lands	• Exclusion of wind and solar energy from "domestic energy resources" deprioritizes clean energy development and stalls decarbonization. • By **fast-tracking permits for oil, gas, coal, etc.,** the order could lead to a substantial rise in GHG emissions. • **Expedited permitting process will reduce environmental reviews** for projects impacting wetlands and waterways, which are critical for carbon sequestration, flood protection, and biodiversity.
EO 14154: Unleashing American Energy	• **Directs federal agencies to encourage energy production on federal lands and waters, remove electric vehicle supports,** and rescinds a number of President Biden's executive orders on energy and the environment. • Also temporarily paused the disbursement of funds from the IRA and IIJA	• As with EO 14156, prioritizing fossil fuels and rolling back environmental protections is **likely to accelerate carbon emissions and undermine climate goals.** • Rolling back NEPA regulations NEPA will limit the consideration of cumulative climate impacts in project approvals. • Rescinding renewable energy policies and pausing IRA and IIJA funding **will hinder clean energy development.**

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Executive order	Summary	Analysis
EO 14148: Initial Rescissions of Harmful Executive Orders and Actions	• **Rescinds 67 executive orders and 11 Presidential Memorandum from the Biden Administration** that covered a range of topics from COVID-19 to immigration policy to climate. • Notable rescissions: EO 14008 of January 27, 2021 (Tackling the Climate Crisis at Home and Abroad) and EO 14027 of May 7, 2021 (Establishment of the Climate Change Support Office)	• Disbanding the Interagency Working Group on the Social Cost of Greenhouse Gases, **removes a critical tool for evaluating the long-term impacts of emissions.** • Rolling back the American Climate Corps **halts training programs for green jobs,** slowing the transition to a low-carbon economy. • Overturning 12 Biden Administration EOs issued to implement environmental justice commitments and certain climate-related provisions of the IRA, **slows or halts environmental justice** efforts. • **Like with EO 14154, this EO targets NEPA** by overturning an EO issued by President Jimmy Carter that spelled out the responsibilities of the White House Council on Environmental Quality).
EO 14213: Establishing the National Energy Dominance Council	• **Establishes the National Energy Dominance Council** with Doug Burgam (Secretary of Interior) as Chair and Chris Wright (Secretary of Energy) as Vice Chair. • Council's purpose is to "advise the President on how best to exercise his authority to produce more energy to make America energy dominant"	• Establishing this new Council **prioritizes fossil fuels over renewable energy sources like wind and solar.** • The council will focus on eliminating "unnecessary" regulations which will likely weaken environmental protections. • The Council's priorities will likely lead to a delayed renewable energy transition and accelerate ecosystem degradation. • The council's focus on fossil fuels prioritizes short-term economic gains at the expense of long-term climate resilience.
Presidential Memoranda: Temporary Withdrawal of All Areas on the Outer Continental Shelf From Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects	• **Pauses all "approvals, rights of way, permits, leases, or loans for onshore or offshore wind projects"** pending review as well as "consideration of any area in the [outer continental shelf] for any new or renewed wind energy leasing." • Directs a **full review of wind leasing and permitting** practices	• This **withdrawal hinders wind energy development,** meaning the US will become even more dependent on fossil fuels and will increase GHG emissions. • This pause will lead to job losses in the renewable energy sector and reduce investment in associated infrastructure. • Uncertainty created by this action will leave the US behind as innovation and investment moves abroad.

WHAT WE'RE WATCHING IN POLICY

Switzerland doubles down on climate action

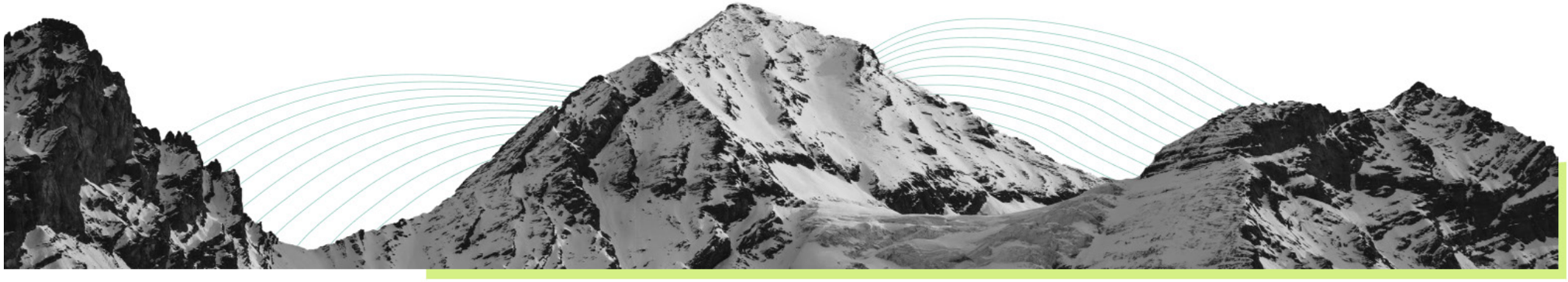
Sarah Braverman

WHY IT MATTERS: This action has taken Switzerland's Paris Agreement commitment to the next level. The country has strengthened its 2023 Climate and Innovation Act with a new Net-Zero Timetables Directive for companies, issued a call for proposals to subsidize carbon mitigation technology, and submitted a more ambitious NDC to the UNFCCC. Despite the difference in obligation for Swiss-based companies and international companies, the Directive sets a baseline for transparency in tracking climate impacts.

In January 2025, Switzerland released a new climate policy mandating net-zero roadmaps for many companies and has upped its NDC. The country also put forth a call for new carbon technology proposals in an effort to boost large-scale investment in climate action across the public and private sectors.

On January 1, 2025, the Swiss government published the Net-Zero Timetables Directive to provide guidance on the development of corporate roadmaps for achieving Switzerland's national goal of emissions neutrality by 2050. This target applies to scope 1 and scope 2 emissions for all non-agriculture Swiss companies. This Directive also introduces a CDR mandate stating that Swiss companies must set CDR targets to offset direct and indirect emissions by 2050, with milestones at five-year intervals leading up to 2050. Using the roadmaps in the Directive is voluntary, unless a Swiss-based corporation is seeking funding from the Climate and Innovation Act. In that case, those corporations are required to use the Directive's net-zero roadmaps.

The Swiss government also launched a call for proposals for carbon management solutions in January, intended to promote technologies that capture CO_2 at point sources or remove it from the atmosphere. The goal of this tender is to enable solutions that will capture and store half a million tonnes of CO_2 by 2030. Funding will be awarded before the end of the year.



WHAT WE'RE WATCHING IN POLICY

State-level policy developments in the US

Thaddeus Woody

WHY IT MATTERS: It is an extremely active quarter at the subnational level as well. In the US, several states are considering legislation related to climate policy. Below, we list several of the bills we're tracking in legislatures across the country. In particular, Virginia passed a suite of new bills related to climate, AI, and data centers, which are covered in more detail here. We are continuing to track a number of live bills across several states that impact carbon removal or the VCM in some form. To paraphrase former Supreme Court Justice Louis Brandeis: states will continue to be the laboratories of democracy when it comes to climate policy.

Bill	Summary	Status
California SB-285: Net zero greenhouse gas emissions goal: carbon dioxide removal: regulations	• Aims to establish regulations for CDR as part of California's efforts to achieve net-zero GHG emissions • **Requires CARB to adopt standards for CDR,** including prohibiting the use of CDR associated with enhanced oil recovery from qualifying as offsets for the purpose of net-zero targets	• Introduced on February 5, 2025 • As of mid-March, **awaiting consideration** in the Senate Committee on Environmental Quality • California legislature adjourns: September 12, 2025
California SB-88: Air resources: carbon emissions: biomass	• **Requires CARB to develop a lifecycle model for quantifying avoided carbon emissions from prescribed burns and wildfires** by January 1, 2028. • Focuses on forest and agricultural biomass to assess the suitability of developing a carbon credit or offset protocol for associated avoided emissions	• Introduced on January 22, 2025 • As of mid-March, **awaiting consideration** in the Senate Committee on Environmental Quality • California legislature adjourns: September 12, 2025
California SB-643: Carbon Dioxide Removal Purchase Program	• **Accelerates CDR deployment by requiring the State of California to purchase US$80 million in CDR credits** by 2030 • Prioritizes projects such as DAC, biomass, enhanced mineralization, and marine CDR • CDR must be durable for at least 100 years to qualify	• Introduced on February 20, 2025 • As of mid-March, **awaiting consideration** in the Senate Committee on Energy, Utilities, and Communications. • California legislature adjourns: September 12, 2025
South Dakota HB 1052: Prohibit the exercise of eminent domain for a pipeline that carries carbon oxide	• **Prohibits the use of eminent domain for CO_2 pipelines** • An effort to hinder the Summit CO_2 pipeline, set to span five Midwestern US states, connect 57 ethanol producers, and transport up to 18 million tonnes of CO_2 per year to be permanently sequestered in North Dakota	• Passed the House in January • Approved in the Senate in March • **Signed into law** March 6, 2025 by Governor Larry Rhoden

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Bill	Summary	Status
Colorado SB25-182: Embodied Carbon Reduction	• **Intends to reduce embodied carbon emission from producing and transporting construction materials** by expanding Colorado's Industrial Clean Energy Tax Credit and the Colorado New Energy Improvement District	• Introduced on February 26, 2025 • As of mid-March, **awaiting consideration** in the Senate Committee on Transportation and Energy • Colorado legislature adjourns: May 7, 2025
New York AB 6566: The Building Embodied Carbon Breakthrough Act	• **Incentivizes the use of low-carbon construction materials, components, and products** by exempting qualifying low-carbon building materials and products from state sales tax. • Requires that materials meet specific GWP benchmarks, as verified by Type III EPDs	• Introduced on February 26, 2025 • As of mid-March, **awaiting consideration** in the Assembly Committee on Ways and Means • New York legislature adjourns: June 13, 2025
New York AB 5660: The Carbon Farming Act	• **Establishes a tax credit for farmers who maximize carbon sequestration** potential through a "carbon farming" land management strategy. • Directs New York Department of Environmental Conservation to develop regulations related to certifying the amount of carbon sequestered or emissions reduced	• Introduced on February 26, 2025 • As of mid-March, **awaiting consideration** in the Assembly Committee on Agriculture • New York legislature adjourns: June 13, 2025
Hawaii HB 976: Renewable Fuels Production Tax Credit	• **Amends the renewable fuels production tax credit by increasing the credit rate** • Specifies that the credit may be claimed for fuels that meet certain lifecycle greenhouse gas emissions and product transportation emissions thresholds • Adds credit values for low lifecycle emissions renewable fuels and sustainable aviation fuels produced • Allows a taxpayer who previously claimed a credit to claim another credit for specified taxable years; amends the credit period to be for a specified period	• Introduced on January 21, 2025 • As of mid-March, approved by the House Committee on Energy and Environmental Protection as well as the Committee on Economic Development and Technology • Currently **awaiting consideration** in the House Committee on Finance • Hawaii legislature adjourns: May 1, 2025

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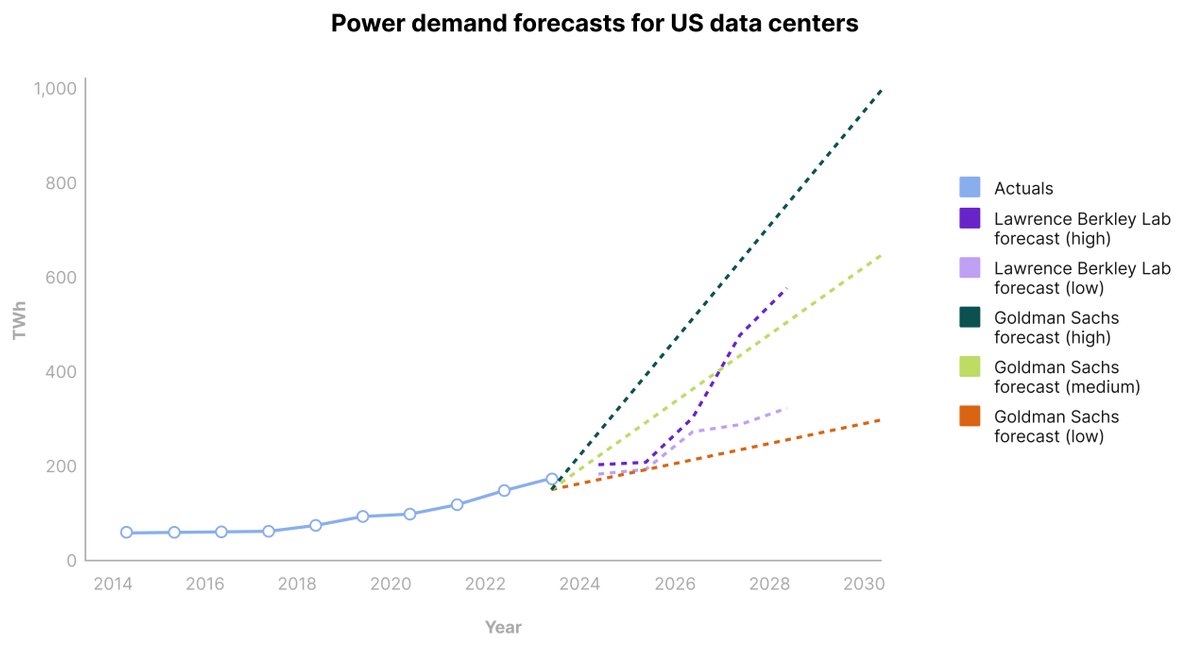
Science insights

SCIENCE INSIGHTS

AI's surging electricity demand and cleaner natural gas

A.J. Simon | Patti Smith | Julio Friedmann, PhD | Adrianna Sutton

BOTTOM LINE: New data center construction and the AI boom have increased electricity demand and heightened the need to decarbonize the power market. We're excited about the potential for natural gas-fired power generation with CCS integration to provide cleaner power. This technology enables stakeholders to stay the course on their climate commitments during this period of intense growth.



Electricity demand in the US is growing more rapidly than at any point in the past two decades. For nearly 40 years, overall power consumption has remained relatively flat. Manufacturing, building electrification, and electric vehicle use, have increased demand in the US since 2019. With accelerated AI development, power grids are being further strained by the proliferation of data centers and their energy demands. Recent forecasts indicate a significant upward trend in peak power usage, with some regions projecting up to 53% greater load by 2037.

Key stakeholders in the emerging AI economy have set ambitious climate targets that will be more challenging to meet as data centers proliferate.



New power development also faces significant challenges, depending on the type of power being provided:

- **New nuclear power** generation requires long development timelines.
- **Geothermal power** is currently limited due to certain regional and drilling constraints.
- **Wind and solar power** are intermittent and do not provide firm capacity without expensive battery storage or complementary power generated by natural gas.

Further, most new grid-connected projects are facing multi-year delays in the interconnection queue. There is currently twice the capacity waiting to be interconnected as is already installed in the US.

A viable option for large electricity users with decarbonization targets, CCS can eliminate up to 95% of the CO_2 emissions from natural gas-fired power generation. Natural gas currently supplies 40% of electricity in the US and is expected to continue playing a major role in the generation mix. Despite the growth of solar and wind power, the intermittency and siting constraints of these clean energy sources mean that natural gas will still play a role in meeting the remaining power demand. When CCS is added to natural gas facilities, carbon capture technologies are used to collect CO_2 from exhaust stacks. Then it is compressed, transported, and permanently stored underground, preventing its release to the atmosphere. However, when planning to integrate CCS with natural gas, stakeholders should consider important factors such as timing, siting, and scale that determine the ability of CCS to deliver firm, low-carbon power:

- **Right time:** Natural gas-fired power plants can be built within 18 months, but fitting them with CCS systems adds 18–36 months to the timeline. Power producers can support the need for rapid deployment of new power generation by building capture-ready natural gas generators that can operate while the CCS system is being built. Streamlined integration of CCS with these facilities can ensure ongoing climate commitments are met.
- **Right place**: These plants can be built in locations where other forms of renewable energy like solar and wind are infeasible due to limited land area. They can also be built strategically close to electricity transmission infrastructure. CCS is suitable for large, natural gas-fired generators that run steadily, and is less effective on smaller plants, or plants that start and stop frequently with significant idle time.
- **Right size:** Natural gas-fired plants fitted with CCS can supply hundreds of megawatts of low-carbon electricity, making them suitable for load applications like data centers. They are most effective when supplying facilities using more than 100 MW of electricity. Large electricity users or consortia of small users are the most appropriate customers. CCS offers strong economies of scale and offers a five-fold reduction in climate impacts compared to natural gas-fired generation without CCS.

Developing these facilities involves complex decision-making regarding costs, life cycle impacts, and various aspects of infrastructure such as transportation, storage, and connectivity to regional grids:

- **Costs:** The current cost of new baseload electricity from natural gas-fired generators without CCS is estimated at $40–70/MWh. Carbon capture technologies include solvents, sorbents, membranes, and oxyfiring, each with varying capital costs, energy use, operating costs, and technical maturity. Generally, adding CCS increases costs from natural gas-fired electricity by 50–100%. However, tax credits like the federal 45Q credit can substantially reduce these costs.
- **Life cycle impacts**: Assessing the full life cycle impacts of these facilities is essential, as CCS does not eliminate climate impacts entirely. Capturing CO_2 is energy-intensive, and can result in lower power generation efficiency or increased fuel consumption. Upstream emissions from natural gas production, processing, and transportation must also be considered. This is particularly true for methane leakage. Emissions from construction, CO_2 transportation, and water use must also be taken into account.
- **Infrastructure**: Transporting captured CO2 to sequestration sites via pipeline, barge, rail, or truck, is a crucial step in the CCS process, with pipelines being the most efficient method. Geologic sequestration involves injecting CO2 deep underground, requiring substantial geologic expertise to develop and operate Class VI wells. Connecting to existing infrastructure such as electrical grids, natural gas delivery networks, and water supplies is critical, requiring careful planning and collaboration with local utilities.

In the face of surging power demand, deploying natural gas-fired power generation with CCS can be a key decarbonization strategy. While CCS technology has not been widely deployed on natural gas-fired power plants yet, with sufficient investment and supportive policy, it could become a significant part of future clean energy supply. It complements existing renewable energy sources, offering scalable, reliable, and low-carbon power. To successfully deploy this option, stakeholders can partner with CCS experts to quantify climate impacts, align power generation with local utilities, determine project feasibility, and initiate concept selection and design to implement effective deployment strategies.

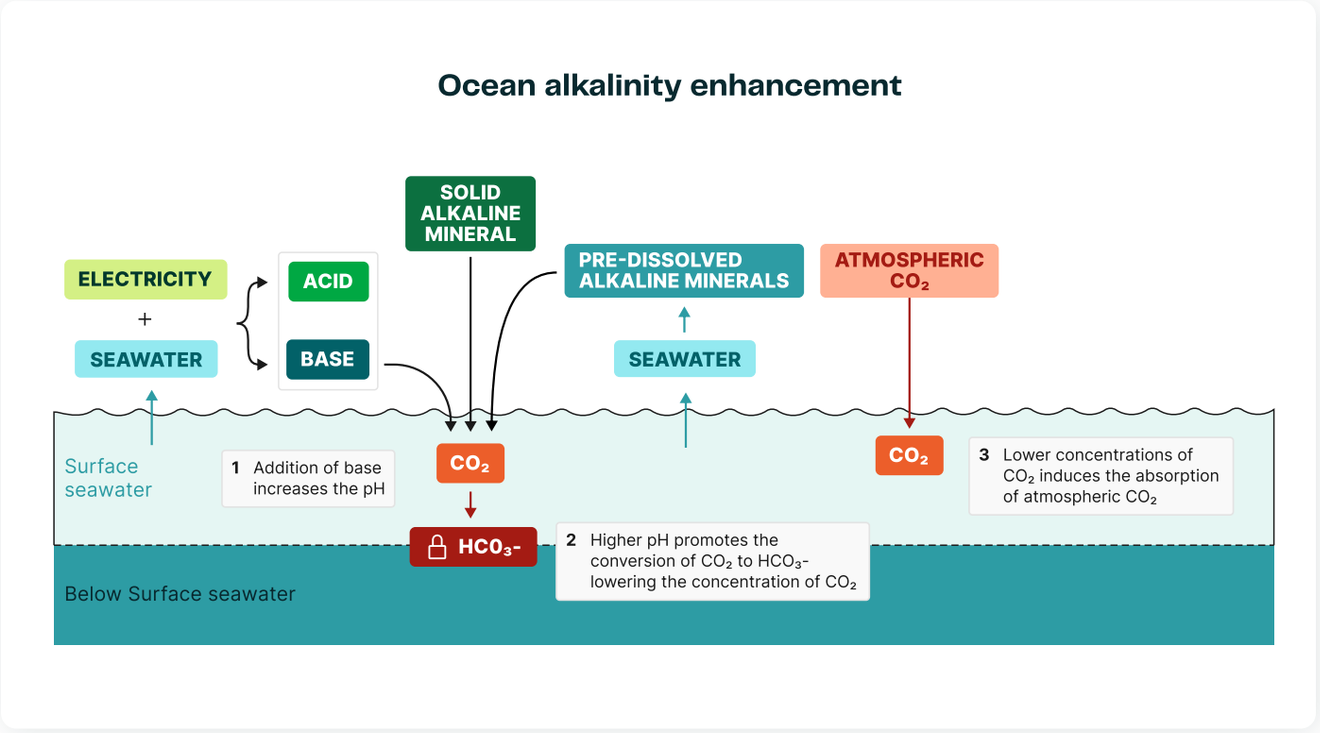


Making waves: mCDR is poised for scale

Antaeres Antoniuk-Pablant, PhD | Adrianna Sutton | Shirin Mavandad

BOTTOM LINE: There is a good chance that more high-quality mCDR tonnes will become available on the market over the next few years. If mCDR companies can successfully address the key challenges outlined here (MRV maturation, understanding ecological impacts, and effective community engagement) the timeline for larger availability could be much closer than was previously expected. Carbon Direct follows the evolution of mCDR technologies, policies, and markets closely and has recently published criteria for high-quality mCDR in collaboration with Microsoft.

Marine-based CDR technologies have the potential to remove carbon on an immense scale. They include approaches involving macroalgae cultivation, artificial upwelling and downwelling, recovery of relevant ecosystems, direct ocean removal, and ocean alkalinity enhancement. Ocean alkalinity enhancement alone has the potential to remove gigatonnes of CO_2 per year. Leveraging and shifting the chemistry of the oceans to support carbon storage is central to all mCDR approaches. This means that MRV for these projects must track carbon within vast and open ocean systems that involve dynamic, complex conditions with interrelated chemistry. This presents significant MRV challenges across all mCDR technologies.



How is mCDR measured?

Developing robust MRV processes for mCDR requires significant investment in direct measurement and modeling. It relies on sophisticated software and hardware to accurately monitor for ecosystem changes and assess shifts in key parameters such as the partial pressure of CO_2 (pCO_2) and ocean pH. For example, discharge of alkalinity into surface seawater comes with several challenges: (1) the dilution of the added alkalinity makes it difficult to measure added carbon against baseline carbon in the ocean, (2) seawater that is depleted of CO_2 must remain at the surface for appropriate periods of time to draw down atmospheric CO_2, and (3) atmospheric CO_2 is gradually drawn down into depleted seawater over a timescale that can range from days to years. These factors alone require sophisticated MRV methods which use in-field seawater sampling and complex ocean models to confer confidence in the quantity of and delivery date for realized CDR. Given the dynamic nature of the ocean environment, observational methods alone will not suffice for comprehensive MRV. It will be essential to invest in and develop fit-for-purpose models that are validated against observational data.

Who pays for MRV development?

However, given the early-stage nature of mCDR, the issue of who will pay for developing and maintaining these MRV systems is not yet resolved. One model is for independent carbon registries and MRV companies, such as the recently announced partnership between Isometric and [C]Worthy, to provide MRV services. Another model is for mCDR suppliers to establish protocols and methodologies themselves, such as the one released by Planetary. A third model could be for governments to establish and oversee an MRV framework, in a vein similar to the California Low Carbon Fuel Standard verification process. MRV development costs include software development and deployment, as well as physical testing for model calibration. Research institutions and governments may have an important role to play in this, but their efforts to date have lagged behind the market.

When will mCDR be viable for offtake?

Some CDR buyers have already procured small amounts of mCDR. Several key uncertainties are hurdles to larger-scale CDR offtake:

- **Developing and standardizing MRV for mCDR:** At-sea testing, refinement and verification of oceanic models, along with supportive research and development initiatives, will help provide crucial data and real-world experience with measuring key variables. Transparency and open sharing on the part of mCDR companies conducting their own research on measurement methods, results, and data analysis methods will help accelerate the maturation and standardization of MRV approaches.
- **Monitoring ecological impacts:** The development of standardized methodologies for predicting and monitoring the health of the oceanic ecosystem and potential impacts from mCDR technologies is key to ensuring safe deployment. Large-scale treatment of seawater to modify alkalinity, or the large-scale introduction of macroalgae growth in the open ocean, may have cascading impacts on marine ecosystems that are hard to predict from laboratory or small-scale experiments. At-sea tests that increase in scale and use best-available scientific instrumentation are needed to assess impacts on phytoplankton, calcifiers (e.g., corals, molluscs), and other marine organisms. This will help researchers and mCDR companies learn about the best way to implement mCDR approaches (including consideration of factors such as location, timing, materials, etc.) that minimize ecological impacts while maximizing net carbon removal.
- **Community and livelihood impacts:** Crucially, successful mCDR projects will need to be closely involved with these communities during planning and governance. Developers have made some important steps toward this goal, but will need to continue expanding and refining their public outreach and community engagement to understand concerns, fully address them, and ensure benefits are allocated in a just and equitable manner.

WHAT WE'RE WATCHING IN SCIENCE

New research highlights

Shirin Mavandad John Dees, PhD

Reining in ERW optimism

Are enhanced rock weathering rates overestimated? ↗

Context tl;dr

ERW is a climate solution that uses ground alkaline materials as a soil amendment to draw down CO_2 from the atmosphere. Some projections suggest that ERW could provide roughly 10% of the CDR needed to limit global warming to below 2°C of pre-industrial temperatures, but uncertainties around carbon accounting remain.

What they found

The authors find that lab-based estimates of ERW's carbon sequestration potential may be overly optimistic due to geochemical and mineralogical complexity.

The wonky details

They identified three main CDR estimation pitfalls: the rapid but short-lived dissolution rates of rock powders, carbonate presence in amendments, and the variability in mineral compositions affecting long-term projections.

Implications

These insights underscore the importance of supporting rigorous field trials and geochemical monitoring to validate ERW's scalability and effectiveness.

What comes next

The article suggests targeted research initiatives to improve confidence in carbon accounting, such as incorporating high-dosage areas that avoid reapplication of rock powders to measure long-term CDR rates, using sensitive techniques to measure accessory carbonate, and measuring carbon for CDR to build confidence in carbon accounting.

Missing the mark on true net zero

Geological Net Zero and the need for disaggregated accounting for carbon sinks ↗

Context tl;dr

CDR is central to global net-zero goals, but which CDR counts in international inventories is still fuzzy. Emissions reporting and targets include land management CDR categories, representing passive CO_2 uptake. The authors assert that these should be disaggregated to better separate the role of passive CO_2 uptake from permanent CO_2 removals stored geologically.

What they found

Many current emissions reporting systems mistakenly count passive carbon sinks (such as natural forest growth and ocean absorption) as part of human-induced carbon removals. This misclassification could allow entities to meet their net-zero targets without truly zeroing out net anthropogenic emissions.

The wonky details

The paper urges a shift toward disaggregated accounting, separating passive natural uptake from active removals. The authors also argue for the concept of Geological Net Zero, which calls for every tonne of CO_2 emissions from fossil fuel use to be removed from the atmosphere and permanently stored in geological reservoirs. They propose that this like-for-like framework ensures that residual fossil fuel use doesn't contribute to long-term warming. Cue lengthy academic debates about the role of nature in CDR goals.

Implications

If passive CDR is counted toward net zero targets, the earth will continue to warm once those targets are met. This matters for both national-level carbon accounting and carbon projects. For nature-based carbon projects, this paper adds a new dimension to the principle of additionality: projects should not count CDR that's going to happen without human intervention, such as through CO_2 fertilization. The paper also emphasizes the important role of durable geological storage in achieving long-term climate goals.

What comes next

The paper suggests that policymakers and carbon markets must adopt rigorous frameworks that track passive uptake separately and exclude passive uptake from net-zero target setting. Furthermore, they call for "a commitment from high-ambition participants to report and scale up" the geologically stored fraction of their net-zero contributions.

Asking the wrong (CDR) questions

"What is CDR?" is the wrong question ↗

Context tl;dr

Much hand-wringing over the past year has focused on delineating which projects count as "true" CDR versus counting simply as reduced emissions. That might be the wrong question to ask. The authors suggest asking instead how effective climate investments are in moving toward a net-negative future.

What they found

The rigid distinction between CDR and emissions reductions is more of a policy and market construct than a meaningful difference in terms of atmospheric impact today. From a climate impact perspective, a tonne is a tonne—whether it is removed or reduced—and every tonne counts until the world reaches net-zero. The debate over classification is often driven by market incentives rather than fundamental climate science.

The wonky details

They identify two major ambiguities in defining CDR. First, many approaches don't directly remove CO_2 but instead slow its return to the atmosphere (e.g., burial of wood to slow or halt decomposition). These methods offer durability and certainty, even if they don't fit strict removal definitions. Secondly, some CDR methods exist within high-emitting systems (e.g., ethanol CCS, ERW in agriculture). Critics argue that categorizing these as CDR risks reinforcing emissions-heavy industries rather than supporting long-term carbon drawdown, while supporters assert that these approaches permanently sequester CO_2. The authors argue that, rather than getting stuck in definitional debates, the more relevant question is: What are you trying to accomplish with your money?

Implications

Rigid definitions for CDR could exclude valuable technologies or create perverse incentives, while overly broad definitions risk diluting the integrity of CDR markets. Additionally, framing investments around whether a system will exist in a net-zero world introduces uncertainties (i.e., what happens in 30–50 years is unpredictable), but investments today must still drive meaningful action.

What comes next

All of this is far from resolved. But the authors suggest we stop worrying about defining CDR as an absolute category, and learn to ask whether a project supports a scalable, durable, innovative, and effective carbon management system.

Originally published as Carbon Direct, which is now Relae. Learn more at relae.co

Market insights

MARKET INSIGHTS

Boons and bugbears in SBTi's draft Net-Zero Standard

Mila Stieglitz-Courtney Meera Atreya, PhD

BOTTOM LINE: The SBTi's proposed updates are a welcome change, with the potential to support industry maturation in the CDR market and bring the Standard into closer alignment with other voluntary and regulatory initiatives, including Switzerland's Net-Zero Timetables Directive. While final guidance will not be expected until early 2026, companies can begin aligning with potential changes by forecasting residual emissions, determining associated CDR volumes for interim milestone years, and securing these volumes through spot-market purchases or forward-offtake agreements.

In March, the SBTi released a draft of its long-awaited Corporate Net-Zero Standard V2.0 for *public consultation*, marking the first major revision to the standard since it was launched in 2021. In V2.0, the SBTi proposes new approaches for companies to support CDR in the transition to net-zero emissions, a move that could prove to be a boon for the nascent CDR industry.

Until now, the SBTi encouraged companies to invest in CDR through mechanisms such as BVCM, but had not formally defined the role of CDR in a company's net-zero strategy ahead of its net-zero target year. As a result, organizations had *little clarity or incentive to invest* in CDR ahead of their *net-zero target date*, dampening near-term demand for CDR and delaying the industry's growth.

Three CDR approaches are up for vote. The new draft changes the SBTi landscape by proposing three ways companies might address residual emissions *before* they get to net zero:

- **Option 1 (requirement):** Companies are *required* to set near-term and long-term removal targets, including interim CDR milestones, to address projected residual emissions.
- **Option 2 (optional with recognition:** Companies *can set and receive recognition* for removal targets to address projected residual emissions.
- **Option 3 (flexibility of mechanism):** Companies *have the flexibility* to address expected residual emissions either entirely through additional emissions reductions within their value chain, entirely through removals, or via a combination of both.

For optional or required removal targets, companies would be expected to gradually increase CDR purchases over time, ramping up to 100% of a company's projected residual emissions when they hit net zero.

Durability is the perennial bugbear in all of this. The SBTi has outlined two options for the minimum durability of CDR purchases. Removals would either need to follow: (1) a like-for-like approach—where CDR storage matches the atmospheric lifetime of residual emissions, or (2) a gradual transition approach—where carbon storage durability increases over time.

While formal recognition of the need for near-term CDR investment is a welcome step, the V2.0 draft has two key limitations: (1) the potential for optional targets, which could keep the market limited to the voluntary efforts of a smaller subset of companies, and (2) the exclusion of scope 3 emissions, which would significantly reduce the scale of both required and optional CDR purchases, particularly given that scope 3 emissions comprise the majority of SBTi signatories' footprints (including those with the greatest willingness to pay).

But wait, there's more. Among other notable revisions, key proposed updates to the Standard include:

- Requiring public disclosure of transition plans after companies set targets
- Separating targets for scope 1 and 2 emissions
- Enhancing scope 3 target-setting frameworks to include additional impact-based metrics and targets, such as share of net-zero-aligned suppliers and activities in procurement
- Recognizing indirect mitigation (e.g., book-and-claim commodity certificates) for hard-to-trace scope 3 emissions
- Providing options to recognize company leadership in BVCM
- Assessing corporate progress against targets to bolster accountability

The *final* V2.0 draft is expected in early 2026, following additional public consultation, road testing, and expert input, with rules expected to go into effect in 2027.



WHAT WE'RE WATCHING IN MARKETS

CORSIA: Market maker for 2025?

Nathan Oalican Sanna O'Connor-Morberg

WHY IT MATTERS: Demand generated by CORISA is anticipated to amount to 36–75 million tonnes of CDR per year. This represents an increase of 20–40% in total demand for 2024 across the VCM, which was about 180 million tonnes. In the last CORSIA EEU auction, Guyanese J-REDD credits sold for nearly US$21.60/tonne. This is approximately five times the price of similar non-CORSIA REDD credits. However, it is unclear whether this price premium will last. If Letters of Authorization become more broadly available this will create downward price pressure for EEUs.

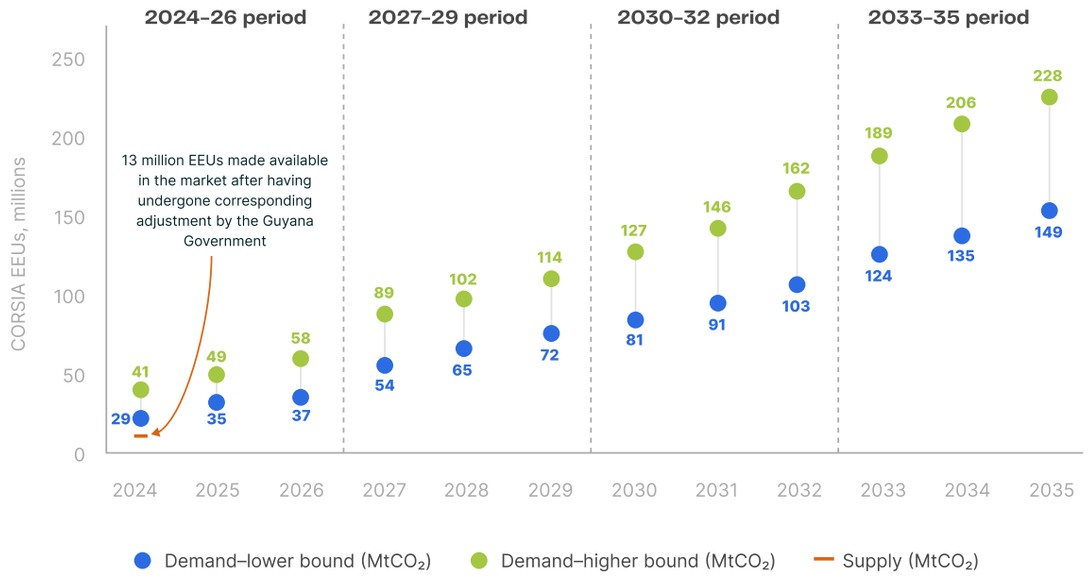
In 2024, CORSIA entered its first phase. Under Phase 1 of CORSIA's compliance period (2024–2026), airlines across 129 participating member countries must limit their annual emissions from international flights to 85% of a 2019 baseline through emissions reductions and offsetting. According to the IATA, by the end of 2026, this may translate to 36–75 million tonnes of CDR demand per year.

In late 2024, the ICAO significantly expanded registry eligibility for CORSIA. Overnight, the total number of registries approved, or conditionally approved, to participate jumped from two to 11, boosting the number of potential CORSIA EEUs to over 200 million credits.

However, the supply of CORSIA EEUs today consists entirely of credits from Guyana's J-REDD program. This supply crunch is complex, but is likely due to a lack of supplier Letters of Authorization, documents issued by host countries that ensure the EEUs will not be counted toward NDCs under the Paris Agreement. As the year progresses, buyers should pay close attention to the issuance of Letters of Authorization and availability of CORSIA EEUs.

Graph of the quarter

In September 2023, IATA flagged in its CORSIA demand projection that EEU supply was limited to Guyanese J-REDD credits and that the delay in issuing Letters of Authorization "imperils airlines' ability to comply with CORSIA." As of February 2025, Guyanese J-REDD remains the only source of CORSIA EEU's. Unless additional Letters of Authorization unlock supply, the industry will be unable to meet projected demand. CORSIA is a key area we're watching this year.



Source: ICAO Council–234th Session

WHAT WE'RE WATCHING IN MARKETS

Japan's new GX-ETS market

Shirin Mavandad Julio Friedmann, PhD

WHY IT MATTERS: By integrating voluntary commitments with regulatory measures, Japan's carbon market is creating new opportunities for investors and businesses. Its evolving system may also serve as a model for other nations and influence international carbon trading, particularly in the Asia-Pacific region.

Japan is demonstrating global leadership by developing a carbon market as part of its strategy to achieve carbon neutrality by 2050. One of the country's key initiatives is the GX-League, launched in April 2022, which includes over 550 companies responsible for more than half of Japan's greenhouse gas emissions. The league encourages voluntary emissions reductions and corporate decarbonization strategies.

The GX-ETS was introduced in April 2023 as a voluntary carbon trading market but will transition to a compliance-based system in 2026, signaling Japan's shift toward stronger regulatory mechanisms. The framework will also introduce auction mechanisms for emission allowances by 2033, aiming to establish a robust market for pricing carbon. While still in its early stages, the GX-ETS is expected to become Asia's second-largest carbon market after China's ETS. By comparison, the EU-ETS, the world's largest, covers around 40% of EU emissions, whereas Japan's system currently operates on a voluntary basis and will expand in scope over time.

Two points stand out regarding the GX-ETS, GX-League, and the Japanese government's efforts:

- **Japan has committed US$1 trillion over 10 years to decarbonization.** You read that correctly, one trillion. Dollars, not yen. This money will be spent on decarbonizing the economy, including significant investments in CDR at home and overseas. It includes pilots for CO_2 shipping, which will be winnowed down to a few big projects. It includes biocoke on steel and low-carbon ammonia imports. Expectations are that nearly all this money will be spent on GX-League member companies.
- **The rules are not set.** Much remains unclear about the GX-ETS rules. These include the cap on domestic industries, the standards for acceptance into the GX-ETS marketplace, and what qualifies as sufficient "Japanese content," especially for investments outside of the country. The evolution of these rules presents a real opportunity for investors and could create significant global partnerships.

In October 2023, the Tokyo Stock Exchange launched a carbon credit market, facilitating the trade of J-Credits, which currently include emissions reduction and efficiency projects rather than large-scale carbon removals. As of January 2024, 249 participants have joined, including 82 members of the GX-League. Japan also plans to implement a carbon levy on fossil fuel importers in 2028, complementing its existing carbon tax of JPY 289 (USD 2.16) per tonne of CO_2. It is unclear how J-credits might correspond with EU-ETS credits, and whether or not some or all J-credits will qualify under Europe's CBAM.

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