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Carbon dioxide removal prices and the challenge of emissions trading system integration

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Policy report

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Contents

Glossary of durable carbon dioxide removal methods

Alkalinity enhancement (AE)	The addition of alkaline materials to increase the alkalinity of rivers and oceans to enhance their natural capacity to absorb atmospheric CO_2 and convert it into stale dissolved carbon forms.
Biochar	A carbon-rich material produced by heating biomass in low-oxygen conditions that can be added to soils to store carbon long-term while improving soil properties.
Biomass carbon removal and sequestration (BiCRS)	The use of biomass to capture CO_2 through photosynthesis and store it in stable forms such as burial or conversion (excluding BECCS).
Bioenergy and carbon capture and storage (BECCS)	The use of biomass for energy production while capturing and storing the emitted CO_2 in geological formations or the deep sea.
Direct air carbon capture and storage (DACCS)	The removal of CO_2 directly from the atmosphere using chemical or physical processes and storing it in geological formations or the deep sea.
Enhanced weathering (EW)	A method that accelerates the natural breakdown of minerals to chemically bind atmospheric CO_2 into stable carbon compounds.
Mineralisation	Converts CO_2 into stable solid carbonate minerals through reactions with naturally occurring or industrial materials.
Marine CDR (mCDR)	Ocean-based methods (excluding ocean alkalinity enhancement) that enhance the ocean's natural carbon uptake and storage processes.

Summary

Meeting net zero emissions by 2050 will require large-scale deployment of carbon dioxide removal (CDR) — technologies that capture carbon dioxide from the atmosphere and store it durably in the Earth's geosphere. However, the market for durable CDR (methods that store captured carbon for centuries to millennia) is still in its early stages, with limited deployment, high costs and little public data on pricing.

To address this evidence gap, we analyse a consolidated dataset covering 43 million tonnes of contracted durable CDR across all major methods and geographies. This provides one of the first system-wide assessments of prices and contract volumes. Our findings show that a rapid upscaling of CDR deployment is necessary.

By the end of 2025, only 1.2% of contracted durable CDR had actually been delivered. Prices for CDR credits remain several times higher than carbon prices in the UK and EU Emissions Trading Systems (ETS) — the markets used to price emissions allowances. Crucially, expected learning rates — the cost reductions typically achieved through doubling of capacity — are very low or even negative for most methods. This suggests the existence of structural bottlenecks rather than technological maturity. As a result, durable CDR costs are unlikely to converge with ETS carbon prices in the near term and may in fact diverge further.

These findings have direct implications for the UK Government's ambition to integrate CDR into the UK ETS by 2029. Carbon Contracts for Difference (CCfD) — long-term government contracts that guarantee a fixed price for carbon removal — will be essential to bridge the gap between current market prices and the cost of CDR. Our estimates suggest that annual subsidy costs could reach approximately US$199 million (around £147 million) between 2028 and 2032 and increase significantly as removal targets scale up.

Policy recommendations

We make the following eight recommendations to UK policymakers, organised under three pillars. These are also relevant to other jurisdictions considering how to integrate CDR into domestic compliance carbon markets:

Driving down CDR costs through continued innovation support

1. Continue to support research, development and demonstration to capture further price reductions across all durable CDR methods.
2. Implement CCfD to bridge the gap between the cost of removal and the carbon price.
3. Make policies technology-specific.

Securing adequate UK supply ahead of ETS integration

4. Governments should enter into offtake agreements, incorporating CCfD, to ensure available durable CDR supply in the UK ETS.
5. Only provide CCfD to suppliers that sell their credits via the UK ETS.
6. Ensure a broad portfolio of CDR methods is ready for integration.

Designing robust governance frameworks that sustain a credible carbon market as removals enter the system

7. Establish guidelines for the integration of removal credits from the offtake agreements of emitters.
8. Continue to pursue efforts to sustain a credible UK ETS.

1. Introduction

What is carbon dioxide removal and why do we need it?

Meeting net zero emissions by 2050 will require the deployment of carbon dioxide removal (CDR) approaches (also referred to as greenhouse gas removal [GGR]). CDR comprises a suite of methods that capture carbon (measured in tonnes of carbon dioxide; tCO_2) from the atmosphere and store it in the biosphere (the regions of the surface and atmosphere of the Earth where life exists) or the geosphere (within the Earth itself). CDR can offset carbon emissions that are technically or economically hard-to-abate or reduce accumulated, excessive emissions from the atmosphere. Accordingly, it is expected to play a major role in mitigating climate change in the future (IPCC, 2023).

CDR can be divided into non-durable and durable approaches. They differ in the length of time they can securely store carbon as well as their cost to capture and store carbon. Non-durable CDR methods, like afforestation and reforestation, store carbon for years or decades cheaply with considerable co-benefits to nature and wildlife. In contrast, durable CDR methods, like bioenergy and carbon capture and storage (BECCS) or direct air capture and carbon storage (DACCS), store captured carbon for centuries to millennia but require considerable research endeavours to capture the first tonne of carbon and major investments to scale up the technologies. The costs of credits for removing 1 tCO_2 from the atmosphere differ considerably across methods and, especially for durable CDR, are notably above the costs of non-durable CDR credits and current emission allowance prices in major compliance carbon markets (i.e. emissions trading systems [ETS]).

As demand for durable CDR is driven by voluntary credit purchases, the high price has been a major hindrance to CDR uptake. Despite this, as our research shows, durable CDR credits saw a notable increase in purchases globally in 2025 via the voluntary carbon market (VCM). By the end of 2025, a total of 45 million tonnes of carbon dioxide ($MtCO_2$) of durable CDR was contracted across all major CDR methods. However, although an upward trend has been recorded in durable CDR credit sales, the question of how to upscale durable CDR remains, with a current delivery rate of only approximately 1.2%. To put this into context, Paris-consistent scenarios that aim to limit global warming to 1.5°C suggest global CDR deployment must increase to 4 gigatonnes of carbon dioxide ($GtCO_2$) by 2030, of which 0.12 $GtCO_2$ is expected to be removed by durable CDR (Lamb et al., 2024).

Scope and structure of the report

This report captures early trends in the nascent but rapidly growing durable CDR market, focusing primarily on volume and pricing. We draw on multiple complementary CDR datasets of credit sales and offtake and prepurchase agreements to construct a consolidated dataset of prices, volumes, methods and geographies. We use revealed prices to characterise and explore potential future price developments across regions and durable CDR methods. The resulting dataset covers 43 $MtCO_2$ of contracted removal across all continents and all major durable CDR methods, including alkalinity enhancement (AE), bioenergy and carbon capture and storage (BECCS), biomass carbon removal and sequestration (BiCRS),[1] biochar, direct air carbon capture and storage (DACCS), enhanced weathering (EW), mineralisation and marine CDR (mCDR) (see the Glossary for brief explanations of the CDR methods).[2] We use the insights gained from the analysis to make eight recommendations to inform and improve policymaking for durable CDR integration into the UK ETS and which will also be applicable to policymakers in other compliance markets.

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[1] Although BiCRS also includes BECCS, we split BECCS from other biomass methods, primarily terrestrial biomass burial.

[2] Note that marine CDR here includes all marine based CDR methods beside ocean alkalinity enhancement, which is the primary method for alkalinity enhancement.

Structure of the report

- **Section 2** explains the role of demand-side policies in advancing durable CDR methods.
- **Section 3** describes the voluntary carbon market and the state of durable CDR globally and in the UK.
- **Section 4** explores learning rates to determine whether they reduce costs or reveal true prices.
- **Section 5** discusses the price gap between CDR costs and ETS prices.
- **Section 6** calculates the policy costs for the UK in financing Carbon Contracts for Difference.
- **Section 7** concludes and details the implications for policymakers.

2. What role for demand-side policies in advancing durable CDR methods?

The development and deployment of CDR methods have reached the political agenda, with national and supranational governments discussing ways to support CDR. The UK Government is leading the way in attempting to upscale CDR through demand-side policies. A cornerstone of the UK's CDR strategy is the planned integration of durable CDR into the UK's compliance carbon market, the UK ETS, by 2029: the UK ETS Authority aims to legislate by the end of 2028, with integration expected to be operational by the end of 2029, subject to further consultation and legislation (UK Emissions Trading Scheme Authority, 2025). To bridge the gap between expected carbon removal costs and the UK ETS price, a carbon contract for difference (CCfD) — a subsidy that adjusts with changes in the sales price achieved by sellers — is planned to cover the difference between the achieved sales price and the cost of removal, to ensure the competitiveness of CDR suppliers (DESNZ, 2025a).

Why use compliance carbon markets to scale up CDR?

Integrating CDR into compliance carbon markets like the UK ETS has two aims: (1) to provide a market for durable CDR (particularly for domestic projects in the case of the UK), and (2) to prepare compliance markets as permits — which allow the permit holder to emit one tonne of carbon dioxide (tCO_2) — become scarce. Cap-and-trade systems like ETSs are designed so that the number of permits available gradually declines, decreasing the allowance for emissions each year, and guiding the economy towards net zero emissions. Permit prices increase simultaneously with their increasing scarcity, meaning that close to net zero, carbon prices become very high. By integrating CDR into the system,[3] the carbon price in the compliance market will be capped at the marginal price of removing a tonne of carbon.

Depending on the successful supply of CDR, linking the release and removal of emissions in a single market could potentially enable net zero emissions before 2050 and ensure net zero is maintained into the future (Rickels et al., 2021), turning the compliance market into a "planetary waste management system" (Edenhofer et al., 2023: p. 2). From the perspective of the CDR supplier, integration into the compliance market could provide a stable, long-term income stream, provided emitters are forced to cover their emissions. However, for the UK ETS to be successful in driving demand for CDR via its integration into the system, the cost of durable CDR needs to be competitive with the prevailing market price of carbon, otherwise credits for CDR will not be taken up because mitigating emissions will be more cost-efficient. To ensure demand, additional instruments like mandates— which require companies to purchase a minimum amount of durable CDR credits to fulfil their obligations — are required or price instruments are needed to cover the cost difference.

The UK Government has created a framework to support the upscaling of durable CDR with their plan to integrate CDR credits into the UK ETS, in addition to subsidising the cost differential between the prevailing ETS price and the cost of deploying CDR. Nevertheless, uncertainty remains over the timing, scale and cost trajectory of CDR supply, as well as the eligibility, permanence and liability arrangements, and, crucially, how removals will interact with cap-setting and market stability — all of which matter for deciding how fast and under what rules CDR should be integrated.

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[3] See La Hoz Theuer et al. (2025) for a discussion and overview of different CDR integration strategies.

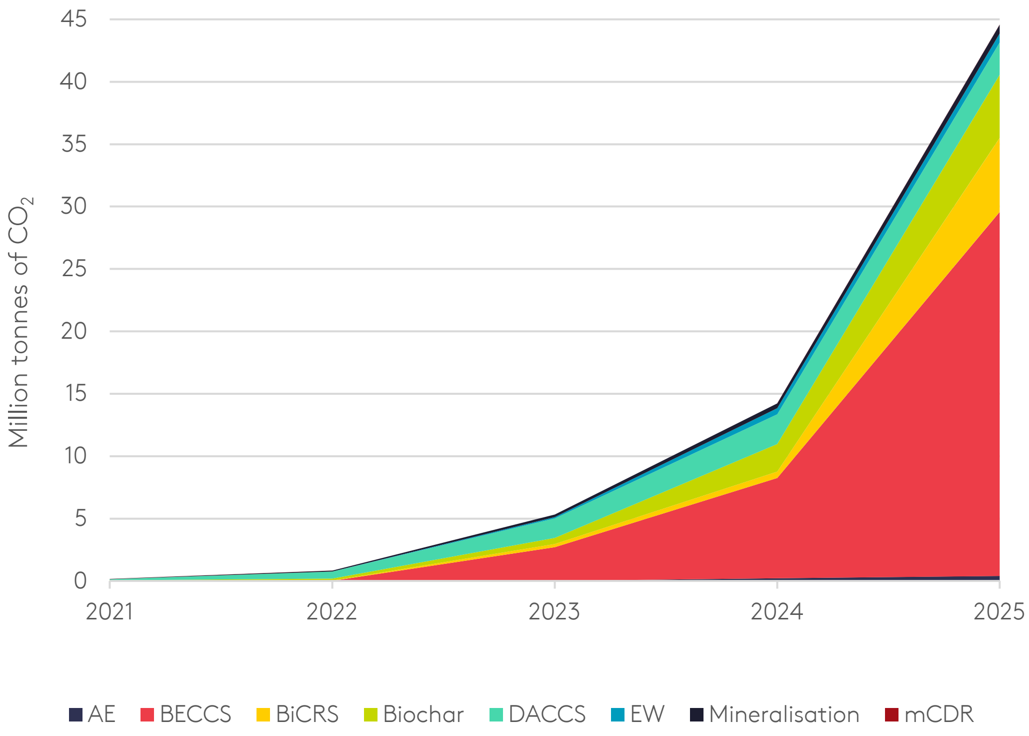
3. Characterising the voluntary carbon market for durable CDR

Durable CDR credits are mainly contracted on the voluntary carbon market — a decentralised market where private actors voluntarily buy and sell carbon credits representing removals or reductions of greenhouse gases from the atmosphere. Despite the recent notable increase in purchases of durable CDR credits in 2025, the market for these remains in its infancy. Although the first volumes are being traded from biochar and BiCRS, the primary sales of durable removal credits are occurring via prepurchase or offtake agreements. These are bilateral agreements that agree a price on future removal, but while prepurchase agreements are primarily small in volume and pay the cost in advance, offtake agreements are larger in volume, and the price is only paid upon receipt of the credit. Accordingly, a prepurchase agreement is a financing instrument and an offtake agreement is a guarantee for future income. Therefore, in this report we use the term 'contracted' to indicate a binding agreement for future removal and the associated 'price' should be understood as an agreed-upon value between parties, not a price discovered through a competitive marketplace.

Global trends in durable CDR

By the end of 2025, a total of 45 $MtCO_2$ of removal from CDR had been contracted, of which 0.5 $MtCO_2$ (1.2%) was delivered. The first recorded CDR sales occurred in 2019. Sales intensified significantly in 2022, with the largest increase in CDR contracts agreed in 2025, around 30 $MtCO_2$ (see Figure 3.1). Of the total contracted tonnes since 2019, 29 $MtCO_2$ come from BECCS, followed by BiCRS with around 6 $MtCO_2$ and biochar with 5 $MtCO_2$. While BECCS contracts are primarily large-scale offtake agreements, BiCRS and biochar credits are already traded and occur in many, smaller-scale transactions — though considerable large-scale agreements have also been made. The least amount of activity is currently recorded for alkalinity enhancement and marine CDR.

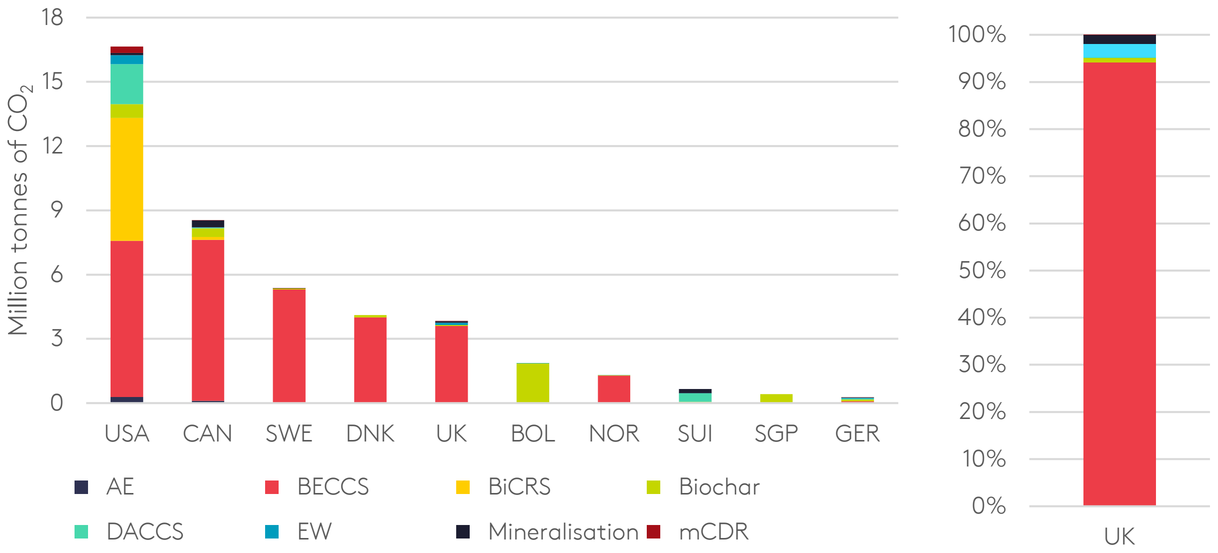
Figure 3.1. Global cumulative contracted durable CDR volumes over time



Sources: Data from CDR.fyi, AlliedOffsets, Sylvera, Frontier, MSCI

CDR activity occurs across the five continents (Africa, Europe, Asia, America and Oceania) but is primarily situated in North America and Europe. The US is by far the most active country when it comes to CDR supply, pursuing removal via all methods (see the lefthand panel of Figure 3.2). The other countries in the top five are primarily BECCS producers: Canada, Sweden, Denmark and the UK. Interestingly, the top five already have demand-side policies in place or have recently announced them, with tax credits in the US and Canada and tenders in Denmark and Sweden (Schenuit et al., 2021; Winkler and Michaelowa, 2026). Other large players in the CDR space include Bolivia and Singapore, which are major removers of carbon via biochar, as well as Switzerland as the market leader in DACCS. Overall, technology- and innovation-driven durable methods like DACCS and BECCS are located in the high-income countries, while biochar is primarily located in emerging markets and developing economies, where the cost of biomass is a key determinant.

Figure 3.2. Contracted CDR volumes for the top 10 countries by method (lefthand panel) and a focus on contracted tonnes in the UK (righthand panel)



Sources: Data from CDR.fyi, AlliedOffsets, Sylvera, Frontier, MSCI

Comparing UK trends and goals on durable CDR

Focusing on UK supply, a total of 3.8 $MtCO_2$ has been contracted across seven methods, with 94% from BECCS, 3% from enhanced weathering, 2% from mineralisation and 1% from biochar. Moreover, the UK also records small amounts of removal via DACCS and marine CDR, while no removal via alkalinity enhancement or BiCRS has been contracted. Accordingly, the UK is relatively competitive in both volume and breadth of CDR.

Comparing these figures with the UK Government's Carbon Budget and Growth Delivery Plan of 0.51 $MtCO_2$ removal annually between 2028 and 2032 and 17.4 $MtCO_2$ between 2033 and 2037 (DESNZ, 2025b), the UK is potentially making good progress towards achieving its target for the first phase. As current sales primarily represent forward commitments for future removals, and we see many offtake agreements with deliveries around 2030, the contracted volumes in 2025 are a good indicator of removal volumes between 2028 and 2032; approximately 0.74 $MtCO_2$ would be removed annually (assuming all contracts are delivered and no additional removal volumes are contracted). However, removing 17.4 $MtCO_2$ annually from 2033 to 2037, as outlined in the Carbon Budget and Growth Delivery Plan (DESNZ, 2025b), requires notable capacity expansion for the UK. This will be difficult considering that the UK's largest bioenergy producer, Drax, has ceased investment in BECCS (Harvey, 2026). Beyond the Carbon Budget and Growth Delivery Plan, the Department for Energy Security and Net Zero's (DESNZ) initial target of deploying 5 $MtCO_2$ by 2030 — which has since been quietly removed — looks increasingly more difficult.

While these values are in line with UK Carbon Budget and Growth Delivery Plan figures, the removal volumes have already been contracted (largely by non-UK entities) and hence, cannot enter the UK ETS, and, depending on the method, cannot be operationalised in national greenhouse gas inventories for international reporting — such as the United Nations Framework Convention on Climate Change (UNFCCC) — as Intergovernmental Panel on Climate Change (IPCC) guidance is currently lacking for most novel CDR, apart from BECCS (Schulte et al., 2023). Instead, additional removals will be needed in the UK. Whether existing capacity will be sufficient depends on how much future supply has already been sold and to whom. Securing UK-based CDR supply will therefore be critical both for meeting national climate targets and for the successful integration of CDR into the ETS. However, by announcing the integration of durable CDR into the UK ETS, the UK Government is sending an important demand signal to create durable CDR supply.

Demand for durable CDR credits has been driven by Microsoft purchasing 39.1 $MtCO_2$, that is, 90% of total contracted CDR volume. So, although corresponding to only 2% of deals, demand is highly concentrated in a single actor in the durable CDR market. With Microsoft's recent announcement to stop contracting in the near-term future (Marsh and Mookerjee, 2026) — having covered their demand for credits — additional demand must therefore be obtained elsewhere. Accordingly, relying on voluntary demand alone to scale up the market for CDR is insufficient. Thus, the integration of durable CDR credits into established compliance markets, like the UK ETS or EU ETS, can provide long-term and steady demand for durable CDR credits.

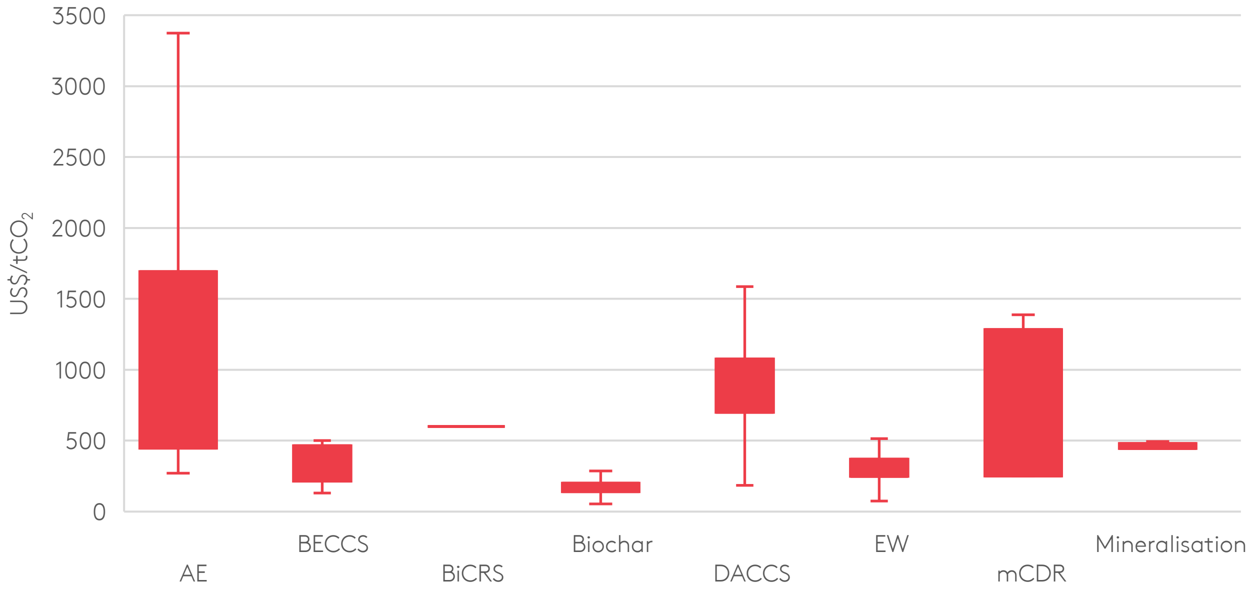
What drives prices?

Since removal is contracted via bilateral agreements, price information is often not disclosed, and in the absence of a unifying, competitive market price, prices vary considerably. Therefore, only 37% of the data has price information, corresponding to 10 $MtCO_2$. Most price information is available for BiCRS and biochar, which are actively traded.

Prices show considerable variation across the different CDR methods in level and distribution (see Figure 3.3). Alkalinity enhancement has the largest price spread and is, on average, also the most expensive CDR at US\$1,064/tCO_2 (range: US\$272–3,750/tCO_2). On the other hand, prices for BECCS are very condensed, with a mean price of US\$330/tCO_2 (range: US\$130–500/tCO_2). BECCS is largely traded via offtake agreements (large volumes, lower prices), reflecting the relative maturity of the technology, as bioenergy plants already exist and only require retrofitting to become BECCS plants. The most competitive CDR to date is biochar, which is notably cheaper than BiCRS at US\$595/tCO_2 (range: US\$44–1,493/tCO_2) despite both being already traded and making deliveries. Rather than unifying across durable CDR methods, prices are technology- and location-specific. Furthermore, prices differ significantly across agreement types, with prices for prepurchase agreements being significantly higher than for offtake agreements. There is not only variation in prices but also in the price drivers.

Durable CDR credit prices are driven by purchase volume, the carbon price, and the type of agreement. Controlling for year of contract and supplier region, an increase in the purchase volume by 1% decreases the CDR price significantly by 0.05% per tCO_2 contracted (see the Appendix for regression results), suggesting that larger market volumes exert downward pressure on prices. In addition, offtake agreements are associated with a 1% downward shift in price levels on average. The agreement type captures firms' ability to realise economies of scale, rather than differences in technological maturity. However, the interaction between offtake agreements and volumes contracted is positive and significant, indicating that, in such contracts, larger volumes are linked to slightly higher prices overall. This can be a premium payment for securing future supply early or a risk premium as future supply is uncertain. Again, notable variation across CDR methods exists: while offtake agreements reduce the price per tonne of removal overall, the price of BiCRS increases by 0.13% for an offtake agreement as, for example, capacity constraints are reached.

Figure 3.3. The price distribution for CDR by method



Sources: Data from CDR.fyi, AlliedOffsets, Sylvera, Frontier, MSCI

To capture climate policy stringency, we match daily allowance prices to credit sales. Specifically, we use the future prices of the EU ETS as it is the largest compliance market; this also captures sudden changes (shocks) in global energy prices caused by disruptions to energy supply, often triggered by geopolitical events. We find that CDR prices are not influenced by the carbon price overall, since the EU allowance price of around US$80/$tCO_2$ is considerably lower than most durable CDR credit prices. However, for biochar, which is actively traded, the EU ETS price matters. Specifically, a 1% increase in the EU ETS price leads to a 0.39% increase in the biochar price. As the carbon price rises, biochar becomes more competitive and thus more in demand, leading to the price increase. The responsiveness to carbon prices, volumes or offtake agreements varies considerably between methods.

Furthermore, we measure price elasticities for CDR credits, focusing on prepurchase agreements only, to avoid any influence caused by supply shocks (which a sudden offtake agreement could signify). Demand for CDR credits is highly elastic in terms of prices; that is, CDR credit purchasers are highly responsive to credit price and carbon price changes, demanding notably fewer credits as prices increase. Across the data, a 1% increase in credit price significantly decreases durable CDR tonnes contracted by 1.8%, and up to 4.6% for BECCS (see the Appendix for price driver values). However, contracting for nascent methods like DACCS, enhanced weathering and mineralisation is not significantly affected. Furthermore, tonnage contracted is also highly responsive to carbon prices, varying strongly across methods: as the carbon price increases by 1%, the volume of durable CDR credits contracted decreases significantly by 3.7% overall and up to 5.9% for enhanced weathering, while it increases significantly for biochar, by 3.1%. As biochar is the most mature and competitive CDR, and hence actively traded, changes in carbon prices have more direct effects on biochar in comparison to costlier methods like alkalinity enhancement or DACCS, which are less responsive to carbon price changes.

4. Learning rates: reducing costs or revealing true prices?

Learning rates measure the cost reduction achieved by doubling produced output (Wright, 1936) and can help predict future costs. Most learning rate estimates are derived from historical deployment data, but since CDR technologies have very little or almost none of these data, we use our future prices to estimate expected learning rates[4] using one-factor learning curves (Rubin et al., 2015; see the Appendix for learning rate calculations).

Comparing CDR learning rates to relevant clean technology benchmarks

Our data reveal that the expected learning rate for durable CDR is 1% and thus prices of durable removal credits are expected to decrease only slightly in the coming years. Low expected learning rates also prevail when examining method-specific learning rates (see Figure 4.1), where several CDR pathways cluster in the low single digits, with some even exhibiting near-zero or negative learning rates (e.g. BiCRS, DACCS, biochar and enhanced weathering), and others such as mineralisation barely reaching +1%. The negative learning rate for biochar reflects rising biochar prices attributed to greater demand for biochar credits, increasing feedstock costs (CO2RE and ERM, 2025), rising carbon pricing as well as a potential initial underpricing of biochar credits. Although the standard assumption is that with increased output, prices decrease due to learning-by-doing, learning can also mean that true costs are being revealed, leading to an upward correction in prices. However, the low or negative learning rates also reveal technical and structural bottlenecks.

Low learning rates are typically associated with mature, highly optimised technologies, yet CDR is a novel clean technology with considerable cost savings to come, according to technology cost forecasting (see e.g. Sievert et al., 2024; Grimm et al., 2026). Therefore, the observed stagnation, and even reversal, points less to technological maturity and more to structural constraints — limited deployment, lack of standardisation, high financing costs and fragmented demand. For example, the negative learning rates (rising costs) of DACCS reveal struggles to upscale and capture economies of scale (see recent news on Climeworks; Rathi and Liu, 2025). Accordingly, CDR appears to be caught in a 'valley of death', whereby scale-dependent cost reductions cannot materialise without sufficient market formation. Overcoming this bottleneck will require targeted policy support to drive deployment, incentivise investment and unlock learning effects.

In comparison, BECCS demonstrates expected learning rates of 8%, similar to wind power (see Figure 4.1). Since most BECCS plants are retrofitted bioenergy plants, the cost of upscaling is not a limiting factor, and firms can already take advantage of economies of scale as captured in the decreasing prices. Despite its expected learning potential, BECCS is likewise struggling to build a lucrative business model as the durable CDR market fails to take off, as revealed by recent news that has seen major expected BECCS producers withdraw their plans to pursue CDR (including Söderenergi in Sweden [George, 2026] and Drax in the UK [Harvey, 2026]).

The two least mature CDR methods, alkalinity enhancement and enhanced weathering, sit at two opposing ends of the spectrum. On the one hand, alkalinity enhancement demonstrates learning rates of 8%, revealing rapid cost reductions resulting from continued innovation gains. On the other hand, enhanced weathering is expected to have high negative learning rates, similar to those recorded for nuclear power (see Figure 4.1). Although some cost savings are expected in the near term, an increase in prices due to diseconomies of scale has been forecast (Kumar and Russell, 2026).

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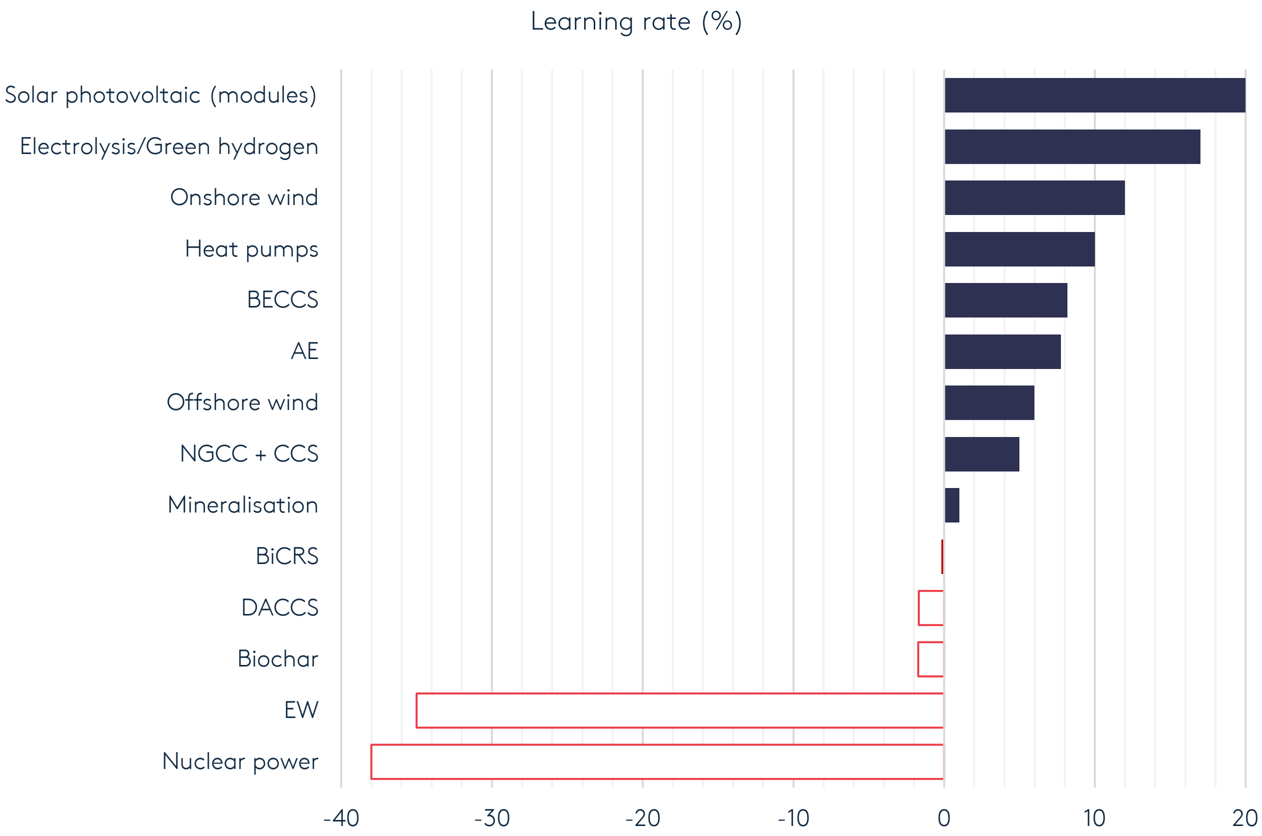
[4] Note that since prices are for future deliveries, there is price expectation embedded in the data and hence, we refer to expected learning rates.

Implications for policy design

Acknowledging that cost reductions may be slow to arise and that not all durable CDR methods are expected to become cheaper in the coming years is important. Policymakers must be aware that policies may not work as intended or will be more expensive than hoped. Optimistic assumptions about learning rates may lead governments to overpay early movers or underpay when learning proves slower than expected. However, this uncertainty is not a reason to delay policy; it is a reason to design deployment cautiously, and use technology-specific policies to reconcile the opposing learning rates. Additionally, it raises the question of how these learning rates translate into future price developments.

Figure 4.1. Comparison between CDR learning rates and relevant technology benchmarks



Notes: The chart is centred on 0%. Left of centre equals costs rising (negative learning). Right of centre equals costs declining (positive learning). NGCC + CCS = natural gas combined cycle + carbon capture and storage.

Sources: CDR learning rates are authors' own calculations based on data from CDR.fyi, AlliedOffsets, Sylvera and Frontier. Learning rates for analogous technologies are from: Roser (2023); Louwen et al. (2018); Hahn Menacho et al. (2022); Rubin et al. (2015); Haas et al. (2023); and Eash-Gates et al. (2020)

5. The price gap between CDR costs and ETS prices

For CDR to become a viable climate change mitigation strategy, it must become competitive with regional carbon prices like the UK ETS or EU ETS permit prices. Bridging the gap between credit prices and allowance prices is important for making durable CDR credits attractive to emitters and for reducing potential policy costs. As durable carbon credit and allowance prices differ considerably, forward sales from prepurchase and offtake agreements for durable CDR provide important insights into price expectations for the coming years.

Combining future price information with expected learning rates reveals a pessimistic picture for durable CDR. The data reveal that prices from durable CDR credits in 2025 were still many times higher than the allowance prices in the EU ETS (around US\$84/tCO_2; £62/tCO_2) and in the UK ETS (US\$66/tCO_2; £50/tCO_2) (ICAP, 2026), and the price spread within individual CDR methods, and thus across firms pursuing similar removal strategies, emphasises the continued nascency of the industry. In addition, expected learning rates reveal price stagnation and even an increase in prices in the coming year (2026). Although carbon prices are expected to increase in the coming decade, it is uncertain whether this increase in the carbon price will be enough to make durable CDR competitive.

The combination of high prices and zero to negative learning rates means that prices are expected to remain stagnant and potentially even rise for many durable CDR methods. In other words, rather than seeing a convergence between carbon prices and removal credit prices, there might be a divergence. Many methods have successfully matured their technologies but are stuck in the ‘valley of death’, unable to move from demonstration to deployment, where cost reductions due to economies of scale can be captured. Upscaling carbon removal potential is, however, not only necessary from a cost perspective but also essential for building the supply of durable CDR needed to ensure net zero emission targets can be achieved.

However, even methods that are currently the most competitive, like biochar and BECCS, are facing serious obstacles. To date, only credits from biochar are actively traded, but, due to their limited supply, prices are rising as demand grows alongside increasing carbon prices. Accordingly, biochar credit prices are expected to continue to increase in the coming years. Nevertheless, since the price increase of biochar credits due to an increase in the carbon price is estimated to be less than the carbon price increase, low convergence can be expected. However, hope remains for BECCS, which, with its relatively low removal cost and expected learning rate of 8%, could become competitive by the middle of 2030. Despite its technical potential, BECCS currently faces an immature market with little demand for removal credits — and this was before the largest buyer, Microsoft, paused its investments in the durable CDR. Uncertainties regarding the transport and storage of captured carbon also remain.

Since our dataset is forward looking, the prices, if contracts are fulfilled, reflect the price of procuring a CDR credit in the coming years. As such, these prices already capture learning rates and potential economies of scale expected by the CDR suppliers. The measured learning rates forewarn policymakers that for CDR to become competitive, additional policies are needed.

6. UK policy costs: financing Carbon Contracts for Difference

Successful integration of CDR credits into compliance carbon markets can only occur if prices are competitive with allowance prices. Where they are not, subsidy payments like CCfD are needed to reduce the credit price of durable CDR and bridge the price gap. Since the UK Government has signalled its intent to subsidise carbon removal activities using a CCfD, it is important to understand the costs of such a policy.

From the price information in our dataset we can roughly calculate the cost of the CCfD. Due to issues of durability, BECCS and DACCS are to be the focus for integration into the UK ETS. With an average price of around US\$66/tCO_2 (£50/tCO_2) in the UK ETS (ICAP, 2026), the CCfD per credit would be roughly US\$234/tCO_2 (£175/tCO_2) for BECCS and US\$754/tCO_2 (£560/tCO_2) for DACCS, assuming constant UK allowance prices and no change in the mean UK credit price. With 0.51 MtCO_2 needing to be removed per year between 2028 and 2032 to be consistent with the Carbon Budget and Growth Delivery Plan, the annual policy cost would amount to US\$119 million/tCO_2 (£88 million/tCO_2) if removal occurred only via BECCS and US\$385 million/tCO_2 (£285 million/tCO_2) if only via DACCS. Using an illustrative ratio of 70:30% BECCS to DACCS (a scenario close to what the UK Climate Change Committee thinks is realistic) suggests a cost of US\$199 million/tCO_2 (£147 million/tCO_2). These numbers are sensitive to the prevailing UK permit price (see Table 6.1). For comparison, to date, the UK Government has provided approximately £100 million for research, development and demonstration of CDR across multiple methods (IEA, 2025).

Table 6.1. Annual CCfD cost assuming different UK allowance (UKA) prices and a credit price of US\$317/tCO_2 for BECCS and US\$908/tCO_2 for DACCS, corresponding to the mean prices recorded for UK suppliers

UKA price (US\$/tCO_2)	100% BECCS (US\$ million/tCO_2)	70:30% BECCS/DACCS (US\$ million /tCO_2)	100% DACCS (US\$ million /tCO_2)
30	137.8	217.5	403.4
66	119.4	199.1	385.0
100	102.1	181.8	367.7

As prices for CDR credits remain notably above the carbon prices of the UK ETS and EU ETS, the subsidy payment per tCO_2 would be considerable. In addition, durable CDR prices are not expected to decrease significantly in the foreseeable future and could possibly increase. Therefore, the subsidy would need to be paid out for a considerable period. Recalling that removal levels are intended to rise to 17.4 MtCO_2 annually from 2033 onwards in the UK, without notable forecasted reductions in the credit price, the financial support to uphold the CCfD could be substantial for the UK Government in later years. To limit the financial burden, the CCfD should not be technology-specific, but reflective of the different technological readiness levels for each method to avoid overpaying as the cost gap differs considerably between methods. Furthermore, as the amount paid out by the CCfD is the difference between the carbon price and the cost of removal, a stable and high UKA price can significantly reduce policy costs and reduce the fiscal pressure of the CCfD. Therefore, a stringent UK ETS will be required to facilitate integration.

Although the policy cost is lower with BECCS only, a portfolio approach should be used to support a variety of new technologies. A portfolio of durable CDR methods balances costs, avoids technological lock-in and thus, protects against delivery failure as well as limiting risks in the case that technological development diverges from expectations. Nevertheless, in the light of possible reversal events, durable methods need to be prioritised for integration. But as technologies like biochar, enhanced weathering or mineralisation mature and uncertainties over monitoring, reporting and verification become less of a barrier, the range of methods for integration and support should be expanded.

7. Conclusions and implications for policymakers

Our analysis of revealed CDR prices and contract data has confirmed that durable removal supply remains scarce, expensive and heavily concentrated in a handful of methods — with costs often several multiples above prevailing ETS prices. These trends are not expected to change in the near term, with prices projected to converge only slowly towards the carbon price, if at all, depending on the method. Strong variation within and across methods adds further complexity, making uniform policy difficult. These realities have direct consequences for policy design. Continued efforts must be made to reduce costs through research and development and large-scale deployment. With the UK Government integrating CDR into the UK ETS, CCfD for the most mature methods will play a vital role in ensuring uptake and should be linked to offtake agreements and delivery safeguards to secure adequate supply ahead of the 2029 integration deadline. The UK is well positioned as an early mover; the challenge now is sequencing policy to match the pace at which supply can realistically scale up.

However, given the nascent state of this market, all findings should be interpreted with caution — data remain sparse and observed prices reflect expectations of future removal that may not materialise. Nevertheless, future prices are very informative as they reveal expectations of market participants and can give first insights into this novel market. Continuous monitoring and regular updating of the analysis will be essential to capture emerging trends and refine the assumptions underpinning climate models.

The following policy recommendations draw on the analyses and results presented above. They focus on achieving the successful integration of CDR into the UK ETS, with particular attention to the near term, as durable CDR has yet to scale up and trading has not yet commenced. Accordingly, the recommendations are structured under three pillars: continuing efforts to reduce CDR costs, ensuring a supply of durable CDR to the UK ETS, and preparing for future integration. While these recommendations focus on the UK context, they can also inform policymakers in other carbon markets that are exploring CDR integration.

Driving down CDR costs

Reducing the cost gap between emission allowance prices and removal costs is important for the successful integration of CDR into the UK ETS. While competitiveness can be expected by around 2040 for some CDR methods, other methods are unlikely to converge with the carbon price in the near future and others may even diverge if recent trends continue. Therefore, it is essential that continued efforts are made to bridge the price gap.

Recommendation 1: Continue innovation, demonstration and deployment support to capture further price reductions across all durable CDR methods. High price forecasts and low (or even negative) learning rates suggest that many methods remain technologically and commercially immature. To ensure that CDR does become competitive, continued support for research, development and demonstration can enable additional cost reductions, thereby lowering the expected fiscal exposure of the CCfD for the UK Government. Additionally, financial support for scaling up CDR is necessary to take advantage of cost reductions from economies of scale and to improve delivery performance.

Recommendation 2: Implement CCfD to bridge the gap between the cost of carbon removal and the carbon price. CCfD subsidise the cost gap between the carbon price and the cost of removal, thereby making expensive CDR comparable in cost to emission allowances. This has already been proposed by the UK Government for integration into the UK ETS (DESNZ, 2025a), but has not yet been agreed upon in the EU context beyond a few member states. CCfD should be allocated via competitive auctions (where feasible) by method and durability to improve price discovery and limit fiscal exposure, while ensuring suppliers can compete with allowances.

Recommendation 3: Make policies technology specific. Due to the strong heterogeneity in development and prices across CDR methods, policies for CDR should be based upon the maturity of each method, both in terms of the level and the duration of subsidies. CCfD is best suited to the most mature technologies but should be extended to other CDR methods as they mature. Where learning rates are high, the core policy implication is the need for early deployment support with a planned exit. For less mature methods, where learning rates are lower and prices are higher, this requires longer policy horizons to ensure investors have the requisite certainty. Additionally, for most methods there is also strong heterogeneity in prices across suppliers employing the same method, that makes comparability across suppliers difficult. This implies the need for bilateral agreements initially, before having technology-specific CCfD when firms are mature enough to compete with other market players.

Ensuring supply of durable CDR in the UK ETS

Integrating durable CDR into the UK ETS will require additional supply beyond that already contracted. Despite the relatively competitive picture of the UK CDR market drawn above, the contracted 3.8 $MtCO_2$ of UK-based removal has already been sold and will hence not enter the UK ETS. Instead, additional removal volumes will need to be generated. The question remains: how much additional capacity of durable CDR exists in the UK and is available for integration into the UK ETS? Additionally, will CDR firms enter the UK ETS at all when they could instead sell their credits on the VCM if both routes are able to access CCfD support, as under current proposals?

Recommendation 4: Governments should enter into offtake agreements, incorporating CCfD, to ensure available durable CDR supply in the UK ETS. In line with other market players, the UK Government should actively seek UK CDR suppliers to supply removal credits to the UK ETS. During CCfD negotiations, the volume of durable CDR to be delivered should also be negotiated to ensure durable CDR credits will be available for integration. However, in comparison to other offtake agreements, the UK Government should only pay for the difference between the strike price — the agreed upon price that a CDR operator will receive from the UK government per tonne of carbon removed — and the UK ETS price. Since there is no upfront payment and the cap will initially remain the same with or without CDR credits, failure to deliver removals will have a limited impact on government expenditure and will be balanced by the allowance supply. Government offtake agreements could also act as a tool to smooth liquidity and price volatility in the early years of CDR integration as the UK Government will be aware of the credits expected to enter the UK ETS.

Recommendation 5: Only provide CCfD to suppliers that sell their credits via the UK ETS. The UK Government is currently proposing to offer CCfD to UK suppliers on the VCM as well as the UK ETS. CCfD effectively guarantee the price per tCO_2 removed for the supplier, which should ideally be covering the marginal cost of removal, and hence, the same price can be obtained in either market. (The price differences across markets change the government top-up but not the per tonne subsidy.) Therefore, CDR suppliers are currently indifferent between the VCM and the ETS. Considering future supply limits, CCfD should be designed so that full support is conditional on UK ETS eligibility and surrender, to ensure subsidised tonnes are available for compliance.

Recommendation 6: Ensure a broad portfolio of CDR methods is ready for integration. While durability will be the priority for near-term integration, having a portfolio of CDR options available is essential for mitigating risks and balancing the costs of achieving net zero emissions. Given the uncertainties, a portfolio approach is also likely to be more robust against the deep uncertainties in learning rate trajectories than one that concentrates everything on the technologies that look most promising today. While the UK appears to be active in most durable CDR methods — with a broader CDR portfolio than most other countries — it does not appear to have an active supply base of marine CDR, including ocean alkalinity enhancement, in our compiled dataset. With its proximity to the ocean and high potential for cost reduction, the UK should use its strategic advantage to advance marine CDR and alkalinity enhancement to build a broad portfolio of CDR methods that can later be integrated into the UK ETS when durability can be verified.

Preparing for future integration

Recommendation 7: Establish guidelines for the integration of removal credits from the offtake agreements of emitters. Many firms are privately pursuing offtake agreements to achieve their own net zero emissions targets. As CDR credits become integrated, there should be a possibility for firms to use their durable CDR credits for compliance within the UK ETS. This is especially pertinent for firms that are not yet included in the UK ETS but are expected to be so soon due to its sectoral expansion; for example, aviation, which is already active in purchasing durable removal credits.

Recommendation 8: Continue to pursue efforts to sustain a credible ETS. As the supply of emission allowances declines over time in line with climate targets, allowance prices are expected to rise. However, there are already increasing calls for lower carbon prices in light of recent energy crises and concerns about industrial competitiveness. To enable the integration of durable CDR credits — and to ensure the overall effectiveness of climate policy — a stable and credible ETS is essential. Once integrated, CDR could help moderate allowance price increases for emitters.

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Appendix: Technical analysis

The data used in this report combine durable CDR trades and agreements from CDR.fyi, AlliedOffsets, Sylvera, MSCI and Frontier. For the analysis we merged the data into a single dataset using StataNow/SE 19.5. We undertook four rounds of cleaning to capture duplicates across the dataset, with a final, manual check to ensure that no duplicates were included. We assumed that there were no duplicates within each dataset, only across datasets. For the analysis, we focused on a subset of the data that contains prices. The summary statistics are given in Table A1.

Table A.1. Summary statistics of the price data for durable CDR credit deals

Method	Total tonnes (tCO_2)	Mean price (US$/$tCO_2$)	Min price (US$/$tCO_2$)	Max price (US$/$tCO_2$)	Total deals	Offtake deals (%)
AE	317,358	1,152.28	271.68	3,750.00	36	25
BECCS	1,654,962	329.43	130.00	500.00	21	71
BiCRS	5,778,962	594.86	43.67	1,492.54	1,136	7
Biochar	1,082,243	184.40	27.78	843.83	748	79
DACCS	814,424	1,000.96	1.00	2,260.00	143	49
EW	320,907	310.42	75.00	1,577.29	136	71
Mineralisation	159,355	589.01	1.00	1,577.29	38	61
mCDR	1,707	728.70	250.00	1,388.89	6	0
Total	10,100,000	474.47	1.00	3,750.00	2,264	39

Price drivers

To study the price drivers for CDR credits, we used a log–log OLS regression with year and region fixed effects and robust standard errors. We then expanded the dataset by additional variables that could potentially improve the explanatory power of later regressions. For this, we added the daily future EU ETS allowance (EUAs) prices to capture climate policy stringency. The regression was run once for the combined dataset (Tot) and then for each method individually. The specific of the method-specific regression looks as follows:

$$\ln(Price_{irt}) = \beta_0 + \beta_1 \ln(CarbonPrice_{irt}) + \beta_2 \ln(Tonnes\ Sold_{irt}) + \sum_{k\neq 2} \gamma_k Agreement\ Typ_{k,i}$$
$$+ \sum_{k\neq 2} \delta_k \big(\ln(Tonnes\ Sold_{irt}) \times Agreement\ Type_{k,i}\big) + \lambda_t + \mu_r + \varepsilon_{irt}$$

The results are shown in Table A.2.

Table A.2. Results of the regression analysis

	Total	AE	BECCS	BiCRS	Biochar	DACCS	EW	Mineral.
	logprice	logprice	logprice	logprice	logprice	logprice	logprice	logprice
logcprice	0.100	1.484	1.214	0.024	0.390***	-0.561	0.495*	-0.235
	(0.111)	(1.201)	(0.849)	(0.021)	(0.147)	(0.414)	(0.258)	(1.106)
logtonnes	-0.053***	-0.072	0.186	-0.007**	-0.064**	0.012	-0.161***	0.045
	(0.007)	(0.075)	(0.142)	(0.003)	(0.025)	(0.039)	(0.047)	(0.241)
Offtake	-1.023***	-0.028	1.578	0.131**	-0.056	0.155	-1.200***	-3.064
	(0.053)	(0.767)	(0.963)	(0.056)	(0.108)	(0.214)	(0.266)	(2.779)
Offtake	0.095***	0.000	-0.260	-0.023*	0.052**	-0.049	0.167***	-0.025
#logtonnes	(0.010)	(0.100)	(0.162)	(0.013)	(0.026)	(0.030)	(0.046)	(0.270)
Constant	6.439***	2.054	0.009	6.074***	4.240***	9.023***	4.261***	9.984*
	(0.427)	(5.747)	(4.637)	(0.444)	(0.516)	(1.595)	(0.942)	(5.675)
N	2,255	36	19	1,135	744	143	135	37
R^2	0.469	0.704	0.702	0.380	0.321	0.121	0.547	0.419

Notes: Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Price elasticity

To study the price elasticities of demand — how quantities demanded change with the price — we ran a similar log–log OLS regression as before though now regressing total tonnes on prices. To avoid any effect from supply shocks, we limited the analysis of the prepurchase agreements. The econometric specification now takes the following form:

$$\ln(Tonnes_i) = \beta_0 + \beta_1 \ln(Price_i) + \beta_2 \ln(Carbon\ Price_i) + \beta_3 OrderYear_i + \varepsilon_i$$

The results are shown in Table A.3.

Table A.3. Price elasticities of demand

	Total	AE	BECCS	BiCRS	Biochar	DACCS	EW	Mineral.
logprice	-1.834***	-2.159***	-4.640**	-3.060***	-0.677***	-0.523	0.455	0.358
	(0.108)	(0.561)	(1.899)	(0.450)	(0.205)	(0.324)	(0.479)	(0.300)
logcprice	-3.736***	-5.515	2.013	-4.358***	-0.106	0.003	-5.121***	2.789
	(0.341)	(3.337)	(4.357)	(0.687)	(0.330)	(1.233)	(0.938)	(3.241)
order_year	1.305***	-0.192	0.757	1.326***	0.348***	0.864***	0.823***	0.346
	(0.060)	(0.375)	(0.620)	(0.093)	(0.077)	(0.225)	(0.213)	(0.282)
Constant	−2610.80***	434.10	−1505.42	−2642.547***	−695.066***	−1741.094***	−1641.498***	−707.388
	(121.71)	(767.37)	(1263.22)	(187.417)	(155.208)	(454.040)	(429.242)	(566.956)
N	2,258	36	21	1,135	745	143	135	37
r2	0.332	0.513	0.467	0.278	0.039	0.136	0.260	0.078

Notes: Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Learning rates

To calculate learning rates, we followed Wright's Law (1936), which is based on a one-factor learning curve:

$$Price \ = \ a * Q^b \ \Leftrightarrow \ln(Y) = a + b \ln{(Q)}$$

where P is the price and Q the quantity. From the log equation we can calculate the learning rate — often referred to as learning-by-doing as it is associated with the price change from an increase in output. The learning rate is defined as:

$$LR = \ 1 - 2^b$$

For our dataset, this implies a simple log–log regression of

$$\ln(Tonnes_i) = \beta_0 + \beta_1 \ln(Price_i)$$