CARBON
NEGATIVE POWER

GLOBAL CO2 EMISSIONS OVER THE LAST 100 YEARS

And the strategic importance of Carbon Credits in Climate Mitigation

Carbon Negative Power

WhitePaper | March 2026

CARBON NEGATIVE POWER
We Build Carbon Negative Power Plants

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1. Executive Summary

Over the past century, anthropogenic carbon dioxide (CO_2) emissions have transformed the Earth's atmospheric composition at a speed and scale unprecedented in human history. Annual global emissions have grown from approximately 3–4 gigatonnes of CO_2 ($GtCO_2$) in the 1920s to more than 37 $GtCO_2$ in recent years, with cumulative emissions since industrialisation exceeding 1,600 $GtCO_2$. The result is an atmospheric CO_2 concentration of over 425 parts per million (ppm) , a level not recorded in at least 3 million years, and a confirmed mean surface warming of approximately 1.36°C above pre-industrial baselines.[1]

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) is unequivocal: meeting the 1.5°C or 2°C warming thresholds established by the Paris Agreement will require not only a dramatic acceleration of gross emissions reductions, but a large-scale deployment of carbon dioxide removal (CDR) technologies. Carbon markets, both compliance and voluntary, have emerged as the primary financial mechanism through which this dual imperative can be pursued at scale.[2]

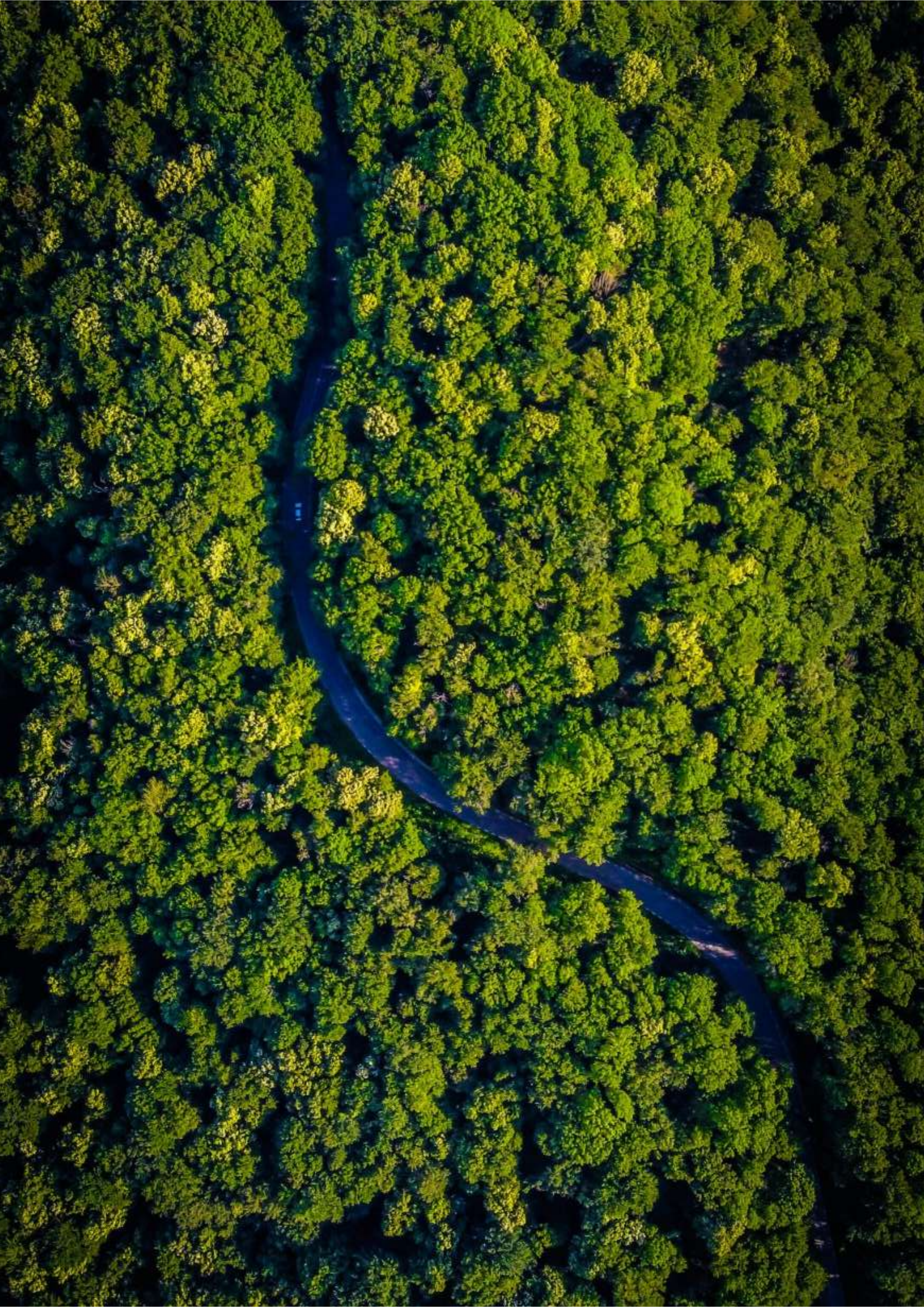
This white paper documents the full arc of the climate crisis: from the historical accumulation of CO_2 emissions across the last century, through the development and current state of global carbon markets, to the strategic investment case for high-integrity carbon removal technologies including biochar. It draws on 20 peer-reviewed academic sources, IPCC assessments, and leading market intelligence from McKinsey, BloombergNEF, and MSCI Carbon Markets.[3]

> **Key Finding:** Carbon removal credits, including biochar, represent the highest-integrity, structurally differentiated segment of the global carbon market, and are projected to command significant price premiums as the market matures toward a removal-first paradigm by 2030–2050.

[1] *BloombergNEF (2024). Long-Term Carbon Offsets Outlook 2024. BloombergNEF. https://about.bnef.com*

[2] Carbon Direct (2024). 2024 State of the Voluntary Carbon Market Report. https://www.carbon-direct.com

[3] *Friedlingstein, P. et al. (2024). Global Carbon Budget 2024. Earth System Science Data, 17, 965–1039. https://doi.org/10.5194/essd-17-965-2025*



2. Introduction: The Century of Carbon

The twentieth century was, in the most literal sense, a century of carbon. The combustion of coal, oil, and natural gas powered the greatest economic expansion in human history, lifting billions out of poverty, transforming cities, and enabling technological revolutions. Yet this expansion came at a profound and now measurable cost: the systematic loading of the Earth's atmosphere with CO_2 at a rate that natural carbon sinks oceans, forests, soils cannot absorb. [4]

The trajectory from 1920 to 2025 encompasses five distinct phases: the slow industrialisation of the early twentieth century; the post-World War II economic boom that accelerated emissions exponentially; the energy crises of the 1970s that modestly interrupted growth; the globalisation era of the 1990s and 2000s, characterised by the rapid industrialisation of China and Southeast Asia; and the current transition period, marked by the rise of renewable energy but continued fossil fuel dependence.[5]

Against this backdrop, carbon markets have evolved from a theoretical concept rooted in environmental economics into a multi-billion-dollar global infrastructure for pricing and financing emissions reductions and carbon removal. Understanding this evolution its achievements, its failures, and its future trajectory is essential for any stakeholder seeking to navigate the economics of the net-zero transition.

3. Historical CO_2 Emissions (1920–2025)

3.1 The Long Acceleration

In 1920, global CO_2 emissions from fossil fuels and industry amounted to approximately 3.8 $GtCO_2$ per year. By 1950, they had reached 6 $GtCO_2$ still a relatively modest burden on planetary carbon cycles. The real inflection point came in the post-war decades. Between 1950 and 1980, annual emissions more than tripled as the United States, Western Europe, and Japan built the infrastructure of mass industrialisation, suburbanisation, and motorised transport.[6]

Global CO_2 emissions in 2022 were 182 times higher than in 1850, reflecting the cumulative effect of industrial civilisation. The Global Carbon Project's annual accounting, the most authoritative dataset in the field, records that 2024 fossil fuel

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[4] *Ganti, G. et al. (2024). Evaluating the near- and long-term role of carbon dioxide removal in meeting global climate objectives. Communications Earth & Environment. https://doi.org/10.1038/s43247-024-01527-z*

[5] *Gross, A. et al. (2024). Long-term biochar and soil organic carbon stability — evidence from field experiments in Germany. Science of the Total Environment, 954, 176340.*

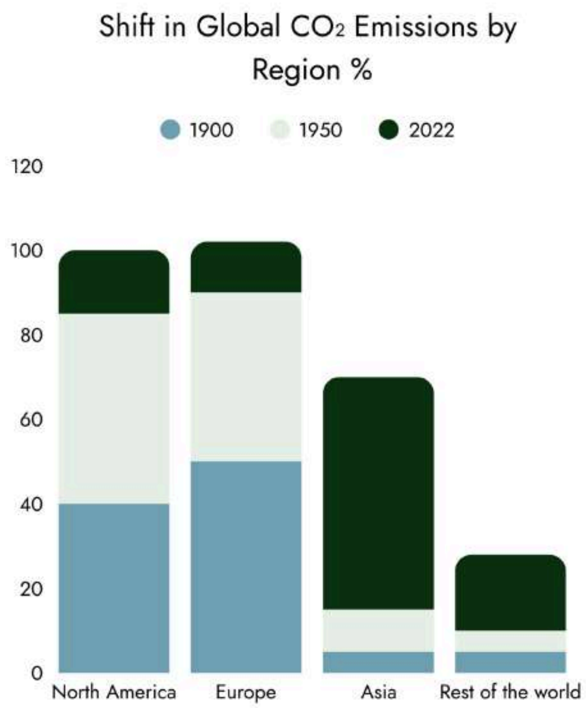
[6] *IEA (2025). CO_2 Emissions — Global Energy Review 2025. International Energy Agency. https://www.iea.org/reports/global-energy-review-2025*

emissions reached approximately 37.4 $GtCO_2$, essentially flat from 2023 and near an historical peak.

3.2 Geographic Shifts in Responsibility

Until the mid-twentieth century, emissions were overwhelmingly concentrated in Europe and North America. In 1900, these two regions produced over 90% of global CO_2; even by 1950, they accounted for more than 85%.This began to change dramatically in the second half of the century as Soviet industrialisation, Japanese reconstruction, and eventually the economic rise of China and India diversified the geographic distribution of emissions.[7]

China surpassed the United States as the world's largest annual emitter in 2005 and, as of 2022, East Asia and the Pacific account for 44% of global CO_2 emissions. Yet when cumulative historical emissions the measure most relevant to atmospheric CO_2 concentrations are considered, Europe and North America remain the largest contributors. The United States and the European Union collectively bear responsibility for the majority of CO_2 currently in the atmosphere.[8] This historical attribution is central to both the ethics and the geopolitics of carbon markets.



[7] IPCC (2021). *Climate Change 2021: The Physical Science Basis. Working Group I, Sixth Assessment Report.* Cambridge University Press.

[8] IPCC (2022). *Climate Change 2022: Mitigation of Climate Change. Working Group III, Sixth Assessment Report. Cambridge University Press.*

Figure 3. *Shift in global CO_2 emissions by region, illustrating the transition from Western industrial economies toward Asia as the dominant source of global emissions.*

3.3 The Role of Land Use and Deforestation

Fossil fuel combustion accounts for approximately 75% of cumulative anthropogenic CO_2 emissions, with land-use change primarily tropical deforestation contributing the remaining 25%.[9] A 2025 reassessment published in Nature found that net emissions from anthropogenic land-use change are higher than previously reported, while the natural land carbon sink is substantially smaller than previously estimated. This finding narrows the remaining carbon budget and amplifies the urgency of engineered CDR solutions.

4. Drivers of Global Emissions

4.1 Fossil Fuels and Industrial Activity

The combustion of coal, oil, and natural gas for energy generation, industry, transport, and heating is the dominant driver of anthropogenic CO_2 emissions. In 2024, natural gas emissions rose approximately 2.5%, the largest contributor to global carbon emissions growth driven by higher consumption in China, the United States, the Middle East, and India. Coal emissions rose 0.9%, driven by growing consumption in China, India, and Southeast Asia, while declining in advanced economies.[10]

The power generation and heavy industry sectors collectively account for approximately 50% of annual global emissions. Transport contributes a further 15–20%, with aviation emissions surging approximately 5.5% in 2024 amid record global air passenger demand.[11] These hard-to-abate sectors are precisely the domains where carbon credits will play the most enduring strategic role.

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[9] *IPCC (2023). AR6 Synthesis Report: Climate Change 2023. IPCC, Geneva.*

[10] *Jones, M.W. et al. (2023). National contributions to climate change due to historical emissions. Scientific Data, Nature. https://doi.org/10.1038/s41597-023-02041-1*

[11] *McKinsey & Company / TSVCM (2021). A Blueprint for Scaling Voluntary Carbon Markets. McKinsey Sustainability. https://www.mckinsey.com*

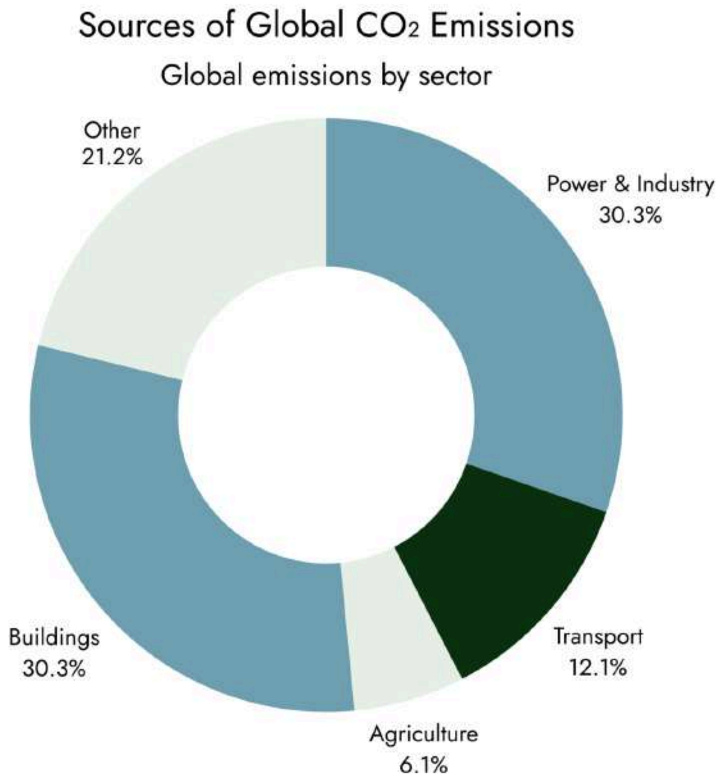

Figure 4. *Global CO_2 emissions by sector, highlighting the dominant role of power generation and heavy industry in driving anthropogenic emissions.*

4.2 Energy Transitions and Their Limitations

The history of global energy transitions illustrates a critical paradox: each successive shift from coal to oil, from oil to gas, and now toward renewables has reduced the carbon intensity of energy production per unit, but has been consistently overwhelmed by growth in total energy consumption. This is the Jevons paradox applied at civilisational scale: efficiency gains enable economic expansion that outpaces the efficiency gain itself.[12]

The current renewable transition differs structurally. In advanced economies, renewables and nuclear together exceeded 50% of electricity generation in 2024, with solar and wind reaching a record 28% share in the European Union surpassing the combined coal and gas share for the first time.[13] Nevertheless, in emerging markets and developing

[12] *Mirzaei, S. et al. (2026). Biochar at the Core of Nature-Based Carbon Management. Energy Science & Engineering, Wiley. https://doi.org/10.1002/ese3.70350*

[13] *Nature (2025). Emerging climate impact on carbon sinks in a consolidated carbon budget. Nature. https://doi.org/10.1038/s41586-025-09802-5*

economies, energy-related CO_2 emissions increased 1.5% in 2024, driven by economic and population growth and continued fossil fuel dependence.

4.3 Population, Development, and Consumption

Global population growth, economic development, and consumption patterns are the underlying drivers of emissions growth. Per capita emissions remain highly unequal: North America's per capita emissions are approximately 3 times the global average, while many high-growth developing nations remain well below it. The tension between development aspirations and decarbonisation obligations is perhaps the defining political challenge of the net-zero transition and the reason well-designed carbon finance mechanisms must direct capital toward the Global South.

5. Atmospheric CO_2 and Climate Impact

5.1 Concentration and Warming

Atmospheric CO_2 concentration reached 425 ppm in 2024 a level not recorded in at least 3 million years of Earth history.[14] The IPCC AR6 Working Group I report establishes that this accumulation has driven a confirmed mean surface warming of approximately 1.1°C above pre-industrial baselines, with more recent data indicating the figure has reached 1.36°C. The relationship between CO_2 concentration and temperature is well-characterised: each doubling of atmospheric CO_2 corresponds to approximately 2.5–4°C of equilibrium warming, a range known as equilibrium climate sensitivity.

[14] OECD (2024). *The Interplay Between Voluntary and Compliance Carbon Markets. OECD Publishing.*

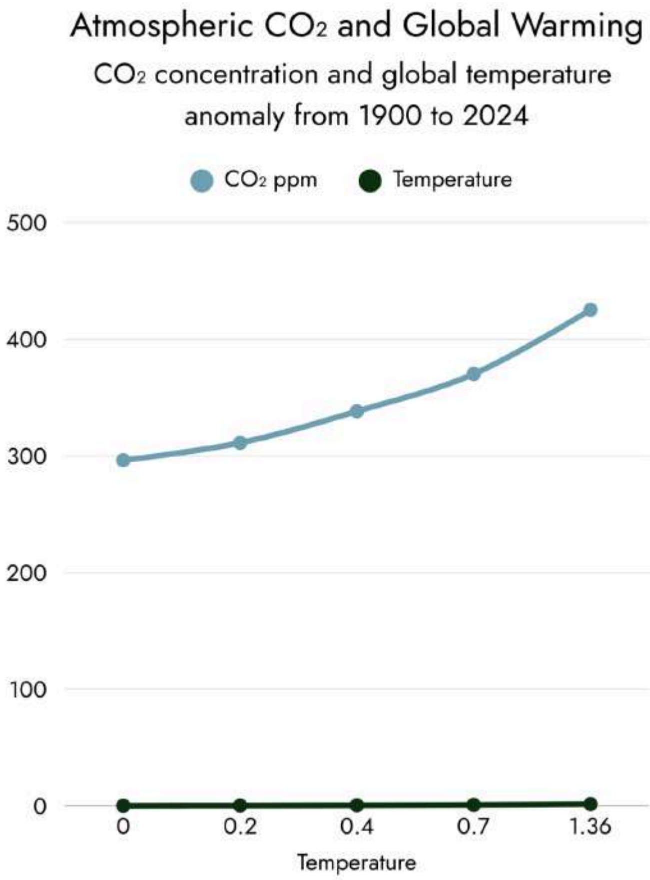

Figure 5. *Atmospheric CO_2 concentration and global temperature anomaly since 1900, illustrating the strong relationship between rising greenhouse gas levels and global warming.*

5.2 Tipping Points and Irreversibility

Of particular concern to climate scientists and policymakers are so-called tipping points: thresholds beyond which elements of the Earth system undergo rapid, self-reinforcing, and potentially irreversible change. The IPCC AR6 identifies several tipping points that may be triggered between 1.5°C and 2°C of warming, including Arctic permafrost thaw (releasing stored methane and CO_2), the destabilisation of the Greenland and West Antarctic ice sheets, and Amazon dieback.

The long atmospheric residence time of CO_2 measured in centuries to millennia means that today's emissions commit the climate system to decades of additional warming regardless of future mitigation actions. [15]This inertia is the fundamental scientific

[15] *Pande, R. (2024). Can the market in voluntary carbon credits help reduce global emissions in line with Paris Agreement targets? Science, 384, eadp5223.*

argument for both the immediacy of emissions reductions and the strategic necessity of permanent carbon removal.

> **Climate Context:** Under current policies, the world is on track for approximately 2.7°C of warming by 2100. Meeting the 1.5°C target requires cutting CO_2 emissions by 48% by 2030 and 99% by 2050, with CDR deployed at scale to counterbalance residual emissions from hard-to-abate sectors (IPCC AR6 Synthesis Report, 2023 [9]).

6. The Emergence of Carbon Markets

6.1 From Kyoto to Paris

Carbon markets trace their institutional origins to the Kyoto Protocol (1997), which introduced three market-based mechanisms: the Clean Development Mechanism (CDM), Joint Implementation (JI), and international emissions trading. These instruments operationalised the economic insight that emissions reductions will occur most efficiently where they are cheapest, a principle grounded in the Pigouvian tradition of internalising externalities through price signals.[16]

The Kyoto framework suffered significant integrity failures, including additionality problems, double-counting, and political instability following the US withdrawal.[16] The Paris Agreement (2015) replaced the top-down Kyoto architecture with nationally determined contributions (NDCs) and established Article 6 as the legal basis for a new generation of international carbon market cooperation. Article 6.4, which creates a centralised UN-supervised crediting mechanism, represents the most significant structural reform in carbon market governance since Kyoto.

6.2 The Architecture of Modern Carbon Markets

Modern carbon markets comprise two distinct but increasingly interconnected segments. Compliance markets including the EU ETS, California's cap-and-trade, and China's national ETS are mandatory instruments covering regulated entities. In 2022, compliance permit markets covered approximately 9 $GtCO_2e$, representing 17% of global emissions.[17]

Voluntary carbon markets (VCMs) allow companies, governments, and individuals to purchase credits outside of regulatory obligations, primarily to support corporate net-zero and carbon-neutral commitments. Between 2018 and 2021, VCM issuances grew nearly fivefold from 75 million to 354 million credits annually. Credit retirements reached 176

[16] Probst, B.S. et al. (2024). *Systematic assessment of the achieved emission reductions of carbon crediting projects. Nature Communications*, 15, 9562.
[17] Puro.earth (2025). *Advancing the Science of Biochar Permanence. https://puro.earth/our-blog/biochar-permanence*

million in 2024, plateauing amid quality concerns but with growing concentration in high-integrity removal credits.

7. Why Carbon Credits Are Critical Today

7.1 The Emissions Gap and Market Role

The gap between current national climate commitments and the emissions trajectory required to meet Paris Agreement targets is one of the most urgent policy failures of our time. The IPCC AR6 Synthesis Report finds that current policies will result in approximately 2.7°C of warming, nearly double the 1.5°C ambition level. Closing this gap requires mobilising private capital at an unprecedented scale and speed, directed toward both emissions reduction and carbon removal projects that would not otherwise attract commercial financing.

Carbon credits perform this function by creating a revenue stream for climate-positive activities whether forest conservation, renewable energy deployment, methane capture, or biochar production that would otherwise lack a viable financial model. For early-stage carbon removal technologies in particular, credit revenue is often the difference between commercial viability and project abandonment.[18]

7.2 Corporate Net-Zero Demand

The corporate commitment landscape has expanded dramatically. By February 2023, over 8,296 companies had signed up to the UN-backed Race to Zero campaign, while the Science Based Targets initiative (SBTi) lists thousands of companies with approved science-based targets. These commitments create structural demand for carbon credits as companies seek to address residual emissions that cannot be eliminated through direct decarbonisation within their operational timelines.

The McKinsey-IIF Taskforce on Scaling Voluntary Carbon Markets estimates that annual global demand for carbon credits could reach 1.5–2.0 $GtCO_2$ by 2030 and 7–13 $GtCO_2$ by 2050, with the market worth upward of $50 billion by 2030. MSCI Carbon Markets projects a wider range of $45–250 billion by 2050, driven by corporate demand for removal credits and the convergence of voluntary and compliance markets.

7.3 Regulatory Tailwinds

Several converging regulatory developments are strengthening the structural case for carbon markets. The European Union's Carbon Border Adjustment Mechanism (CBAM)

[18] *Ritchie, H., Roser, M., & Rosado, P. (2024). CO_2 and Greenhouse Gas Emissions. Our World in Data. https://ourworldindata.org/co2-and-greenhouse-gas-emissions*

creates a carbon price for imported goods, effectively extending the EU ETS to trading partners. SEC climate disclosure requirements in the United States are increasing corporate accountability for emissions claims. National carbon pricing systems are expanding across Asia, Latin America, and Africa. And the Article 6.4 mechanism, once operational, will integrate sovereign demand into the voluntary market architecture, creating new institutional buyers with long-duration procurement horizons.[19]

8. Limitations and Critiques of Carbon Credits

8.1 The Integrity Crisis

The voluntary carbon market entered a period of significant credibility crisis beginning in 2022–2023. A landmark meta-analysis published in Nature Communications synthesised 14 experimental studies covering 2,346 carbon mitigation projects representing nearly 1 billion tonnes of CO_2e. It found that fewer than 16% of carbon credits issued to the investigated projects constitute real emission reductions: 11% for cookstoves, 25% for avoided deforestation (REDD+), and 68% for industrial HFC-23 abatement.

These findings were consistent with investigative reporting that found the majority of Verra's REDD+ avoided deforestation credits had substantially overstated their climate impact. The result was a 56% collapse in VCM transaction volume from 2022 to 2023, with the average credit price falling to approximately $6.53 per tonne.[2] The market has not yet recovered its peak volume, though the composition of demand has shifted decisively toward higher-integrity credits.

8.2 Structural Problems: Additionality, Permanence, and Leakage

The three most substantive structural critiques of carbon credits are consistently identified across the academic literature:

- **Additionality:** Whether the emissions reduction or carbon removal would have occurred regardless of carbon credit financing. If an avoided deforestation project protects forest that was never credibly threatened, the credit has no additionality.
- **Permanence:** Whether the sequestered carbon will remain stored. Forest credits are particularly vulnerable to wildfire, disease, and political instability. The 2021 Bootleg Fire in Oregon destroyed forests that had generated millions of California offset credits.
- **Leakage:** Whether protecting one forest simply displaces deforestation elsewhere. Leakage rates in tropical forest projects are estimated at 10–42% of stated benefits.

[19] *Rodrigues, L. et al. (2023). Modelling biochar long-term carbon storage in soil with harmonized analysis of decomposition data. Science of the Total Environment.*

8.3 Industry Response and Reform

The industry's response has been substantive. The Integrity Council for the Voluntary Carbon Market (ICVCM) published its Core Carbon Principles (CCPs) in 2023, establishing a minimum quality floor for credit generation across all major standards. Ratings agencies including BeZero Carbon, Sylvera, and MSCI Carbon Markets now provide independent quality scoring for individual projects.[20]

A key finding from Carbon Direct's 2024 State of the VCM Report is instructive: while the overall market grew only 3% from 2022 to 2023, the market for carbon removal credits grew 50%. This divergence signals the structural shift underway from a market dominated by cheap, low-integrity avoidance credits toward one anchored by verifiable, permanent removal.

9. The Role of Carbon Removal: Biochar and Carbon-Negative Technologies

9.1 The IPCC Mandate for CDR

The IPCC AR6 Working Group III report is unambiguous: the deployment of CDR to counterbalance hard-to-abate residual emissions is "unavoidable" if net-zero CO_2 or GHG emissions are to be achieved.[8] All scenarios consistent with limiting warming to 1.5°C require cumulative CDR of hundreds of gigatonnes by 2100. The scale of this requirement estimated at 5–10 billion tonnes of annual removal by 2050 represents one of the largest infrastructure and investment challenges in human history.

Afforestation and reforestation play an important near-term role, accounting for approximately 10% of net GHG reductions between 2020 and 2030 in 1.5°C-consistent pathways.[4] However, novel CDR technologies direct air capture with geological storage (DACCS), enhanced weathering, and biochar must scale to multi-gigatonne levels by 2050 to address the residual removal burden that nature-based solutions alone cannot meet.

9.2 Biochar: The Evidence Base

Biochar, the carbonaceous material produced by the pyrolysis of organic biomass under low-oxygen conditions, occupies a uniquely advantageous position in the CDR landscape. It combines demonstrated permanence at century-to-millennial timescales with verified agricultural co-benefits, relatively low production costs, and an established and growing carbon crediting infrastructure.[12]

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[20] *Trouwloon, D. et al. (2023). Understanding the use of carbon credits by companies. Global Challenges, Wiley. PMC10069309.*

The scientific basis for biochar permanence rests on the highly condensed aromatic carbon structure produced during high-temperature pyrolysis. The presence of charcoal in archaeological artefacts and geological records provides empirical evidence that biochar can persist for millennia under appropriate conditions. The molar hydrogen-to-organic-carbon (H/C) ratio has become the primary practical proxy for stability: lower H/C ratios indicate greater aromaticity and longer carbon residence times. Puro.earth's 2025 methodology update now certifies biochar credits as CORC200+, guaranteeing carbon removal for several centuries.[21]

A global meta-analysis of 75 studies found that biochar application increases soil carbon sequestration by an average of 61% (confidence interval: 36–90%), while leaving total microbial respiration statistically unchanged meaning the carbon gain is not offset by accelerated decomposition of native soil organic matter. Long-term field experiments confirm that the permanence of sequestration is primarily determined by biochar quality and the soil type into which it is incorporated.

9.3 Biochar's Competitive Position in CDR

Compared to alternative CDR pathways, biochar offers a compelling combination of attributes:

- **Cost-competitiveness:** Biochar can be produced for $50–200 per tonne of CO_2 equivalent at scale, compared to $300–1,000/t$CO_2$ for DACCS at current technology readiness levels.
- **Measurement precision:** H/C ratio testing and thermogravimetric analysis provide direct physical characterisation of carbon stability, enabling credit-by-credit verification a significant advantage over nature-based solutions that rely on modelled baselines.
- **Agricultural co-benefits:** Biochar improves soil pH, water-holding capacity, cation exchange capacity, and nutrient retention, generating agricultural productivity gains that provide a second revenue stream independent of carbon credits.
- **Waste stream utilisation:** Biochar produced from agricultural and forestry residues, as in Carbon Negative Power's gasification process, directly avoids the methane and CO_2 emissions that would result from biomass decomposition or open-field burning.

> **Carbon Negative Power:** CNP's integrated gasification plants convert agricultural and forestry waste into baseload green electricity, biochar, and verified carbon credits simultaneously. This triple-output model creates multiple

[21] *West, T.A.P. et al. (2023). Action needed to make carbon offsets from forest conservation work for climate change mitigation. Science, 381, 873–877.*

revenue streams from a single waste feedstock, and positions each plant as a genuinely carbon-negative energy asset.

9.4 Standards and Market Positioning

The carbon credit standards landscape for biochar has matured significantly. Puro.earth, the originator of engineered CDR certification, now operates a CORC200+ biochar methodology that requires H/C ratio testing and third-party auditing. Verra's VM0044 methodology provides broader coverage but has faced scrutiny over feedstock assumptions. Gold Standard applies a permanence correction factor that discounts long-term value. The forthcoming Article 6.4 mechanism is expected to establish a quality floor that naturally favours high-permanence engineered removal credits over low-permanence avoidance credits.

10. The Future of Carbon Markets

10.1 Market Scaling Projections

The consensus among leading market analysts is that the voluntary carbon market, despite its current contraction, is poised for substantial long-term growth driven by the convergence of regulatory pressure, corporate net-zero commitments, and tightening credit quality standards that will progressively eliminate low-integrity supply.

BloombergNEF's Long-Term Carbon Offsets Outlook 2024 models three scenarios. In the high-integrity scenario where integrity reforms succeed and credit demand becomes price-inelastic, prices reach $238/tonne by 2050 and the market is valued at over $1.1 trillion annually. Under a removal-only scenario, prices reach $146/tonne by 2030 and $172/tonne by 2050, with the market valued at $884 billion annually. Even the most conservative scenario implies fundamental demand growth of 15-fold or more relative to 2024 levels.

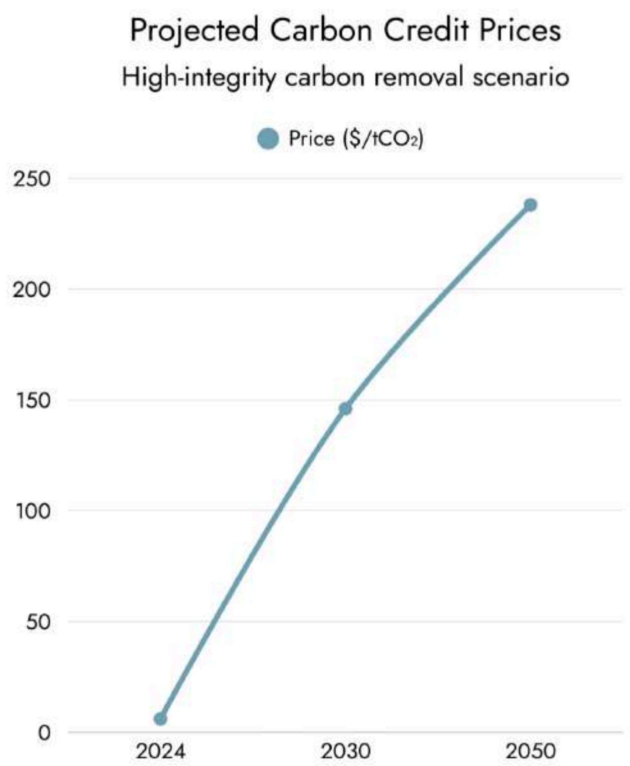

Figure 11. *Projected carbon credit price trajectories under high-integrity carbon removal scenarios, reflecting expected demand growth and tightening supply of durable removal credits.*

10.2 The Structural Shift to Removal

The most significant structural trend in the voluntary carbon market is the progressive shift from avoidance-based to removal-based credits. This shift is driven by several converging forces:

- **Academic and standards guidance:** The SBTi and Oxford Principles for Net Zero Aligned Offsetting both require that corporate net-zero claims be supported by removal credits in the long run.
- **Scientific consensus:** The IPCC's clear articulation that net-zero requires net-negative CO_2 for a period establishes removal as a structural necessity, not an optional supplement.
- **Reputational and legal risk:** Investigative scrutiny of REDD+ and cookstove credits has made corporate legal and reputational exposure from avoidance credits acutely visible. Delta Air Lines faced a class-action lawsuit in 2023 over its carbon-neutral claims based on Verra credits.

- **Concentrated early demand:** High-durability carbon removal pre-purchases were 40 times oversubscribed relative to spot market availability in 2024, with Microsoft accounting for 80% of all high-durability offtake agreements.

10.3 Investment Implications

For investors and project developers in the CDR space, the market signals are clear: removal credits command and will increasingly command a structural premium over avoidance credits. The removal market grew 50% in 2023 while the broader VCM declined. Corporate buyers are signing multi-year forward offtake agreements at prices significantly above the spot market average. The regulatory trajectory CBAM, SEC disclosure, Article 6.4, national carbon pricing expansion systematically favours assets that can generate verified, permanent, physically measured removal credits.

The carbon credit revenue stream from a well-designed CDR project has characteristics that are unusual among climate investments: it is policy-supported, long-duration, inflation-linked, and not correlated with energy commodity prices. For development finance institutions seeking diversified exposure to the net-zero transition, CDR credit assets offer an analytically distinct risk-return profile.

11. Conclusion: The Economics of Carbon Removal

The scale and pace of CO_2 accumulation over the past century has created a climate debt that cannot be repaid through emissions reductions alone. The IPCC is explicit: CDR is not optional. The question is not whether carbon removal will be deployed at scale, but who will finance it, who will build it, and at what price it will be compensated.

Carbon markets voluntary and compliance are the primary mechanism through which the answer to that question will be determined. The market is imperfect, has suffered significant integrity failures, and remains small relative to the scale required. But it is the infrastructure that exists, that is actively being reformed, and that is attracting substantial and growing capital.

Within the carbon market, the structural shift toward high-integrity removal is already underway and will accelerate. Biochar with its combination of physically measurable permanence, agricultural co-benefits, moderate production costs, and established crediting standards represents one of the most credible near-term CDR solutions available. For operators like Carbon Negative Power, whose gasification technology produces biochar as an integrated byproduct of carbon-negative power generation, this creates a uniquely advantageous commercial position.

The economics of carbon removal are not charity. They are the rational pricing of a genuinely scarce asset: verified, permanent, measurable atmospheric CO_2 removal. As net-zero deadlines approach, as regulatory frameworks tighten, and as the supply of high-quality removal credits remains constrained, the economic case for early-mover investment in this space is compelling and strengthening.

> **Strategic Conclusion:** The intersection of climate necessity, regulatory momentum, and market maturation creates a structural window for carbon-negative power and removal technologies. Projects that can demonstrate genuine, measurable permanence backed by physical science, independent verification, and credible standards are positioned to benefit from the most significant re-pricing of a climate asset in history.

www.carbonnegativepower.com

For more information about developing carbon removal projects:

Carbon Negative Power

contact@carbonnegativepower.com

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[4] Ganti, G. et al. (2024). Evaluating the near- and long-term role of carbon dioxide removal in meeting global climate objectives. Communications Earth & Environment. https://doi.org/10.1038/s43247-024-01527-z

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[10] Jones, M.W. et al. (2023). National contributions to climate change due to historical emissions. Scientific Data, Nature. https://doi.org/10.1038/s41597-023-02041-1

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[13] Nature (2025). Emerging climate impact on carbon sinks in a consolidated carbon budget. Nature. https://doi.org/10.1038/s41586-025-09802-5

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[16] Probst, B.S. et al. (2024). Systematic assessment of the achieved emission reductions of carbon crediting projects. Nature Communications, 15, 9562.

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