climeworks

Pioneering the race to zero:

Key strategies and innovations to scale up carbon dioxide removal

Carbon removal not only aids in fighting climate change but also creates new industries and jobs, enhancing the socio-economic landscape.

Climeworks is leading the way for this industry. We delivered this year the world's first third-party verified carbon dioxide removal, setting a new standard and advocating for high-quality carbon removal practices.

By 2050, high-quality, durable carbon removal will dominate carbon credit portfolios, emphasizing the long-term importance and growth of this industry.

Jan Wurzbacher & Christoph Gebald
Co-CEOs and Co-Founders of Climeworks

1 In the face of a climate emergency, science demands carbon removal

There is an immediate need to address global warming, with record temperatures signaling a climate emergency. Last year was the warmest year since we recorded the temperature, at 1.48°C above pre-industrial levels.

To reduce CO_2 emissions and have a chance to stay within the 1.5°C limit, we need a comprehensive strategy involving emission reductions, changes in the food system, and natural carbon removal.

An IPCC assessment suggests a remaining budget of about 420 gigaton CO_2 for a two-thirds chance of limiting warming to 1.5°C. 5 drivers from this carbon budget can help restrict CO_2 emissions and thus mitigate the climate emergency:

"Companies would be well advised to realize that in the long term, there are fewer profits to be made on a planet on fire."

Dr. Akshat Rathi
Senior reporter for Climate, Bloomberg Green,
Author of "Climate Capitalism"

1. Limit fossil fuels

A limit of 250 gigatonnes of CO_2 emissions is set to achieve massive emission reductions and phase out fossil fuels.

2. Transition food system and agricultural

The food system must undergo significant changes to remove 5 gigatonnes of CO_2 annually from the atmosphere.

3 & 4. Protect land and ocean biosphere

Both the biosphere and oceans are natural components that each remove approximately 25% of our yearly CO_2 emissions from the atmosphere.

5. Use carbon removal

The carbon removal industry must scale to 6 to 16 gigatonnes per year within the next 25 years to meet net zero by 2050, involving technologies like direct air capture.

Carbon budget components: **Climeworks is committed to leading the race to net zero**

≈250	+4±2.6	-10.6	-11	-5 — -10
Gt*CO_2	GtCO_2/yr** →≈5GtCO_2/yr	GtCO_2/yr (≈25%)	GtCO_2/yr (≈25%)	GtCO_2/yr (by 2nd half of this century)
Fossil fuels	**Agriculture**	**Land Biosphere**	**Ocean Biosphere**	**Technologies CO_2 removal**





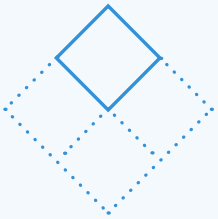
*Gt=gigatonnes
**yr = year

Source: Rockstrom et al 2023

2 Technological advancements in carbon removal and collaboration will allow the scale needed

Five success factors will be decisive in making carbon removal a gigaton game.

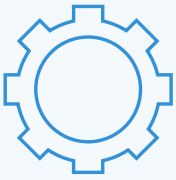
Land / storage availability



Energy

Cost

Technology



Market readiness

1. Land and storage capabilities are available for carbon removal globally

Essential for carbon removal, over nine billion tons of storage volume are available globally.

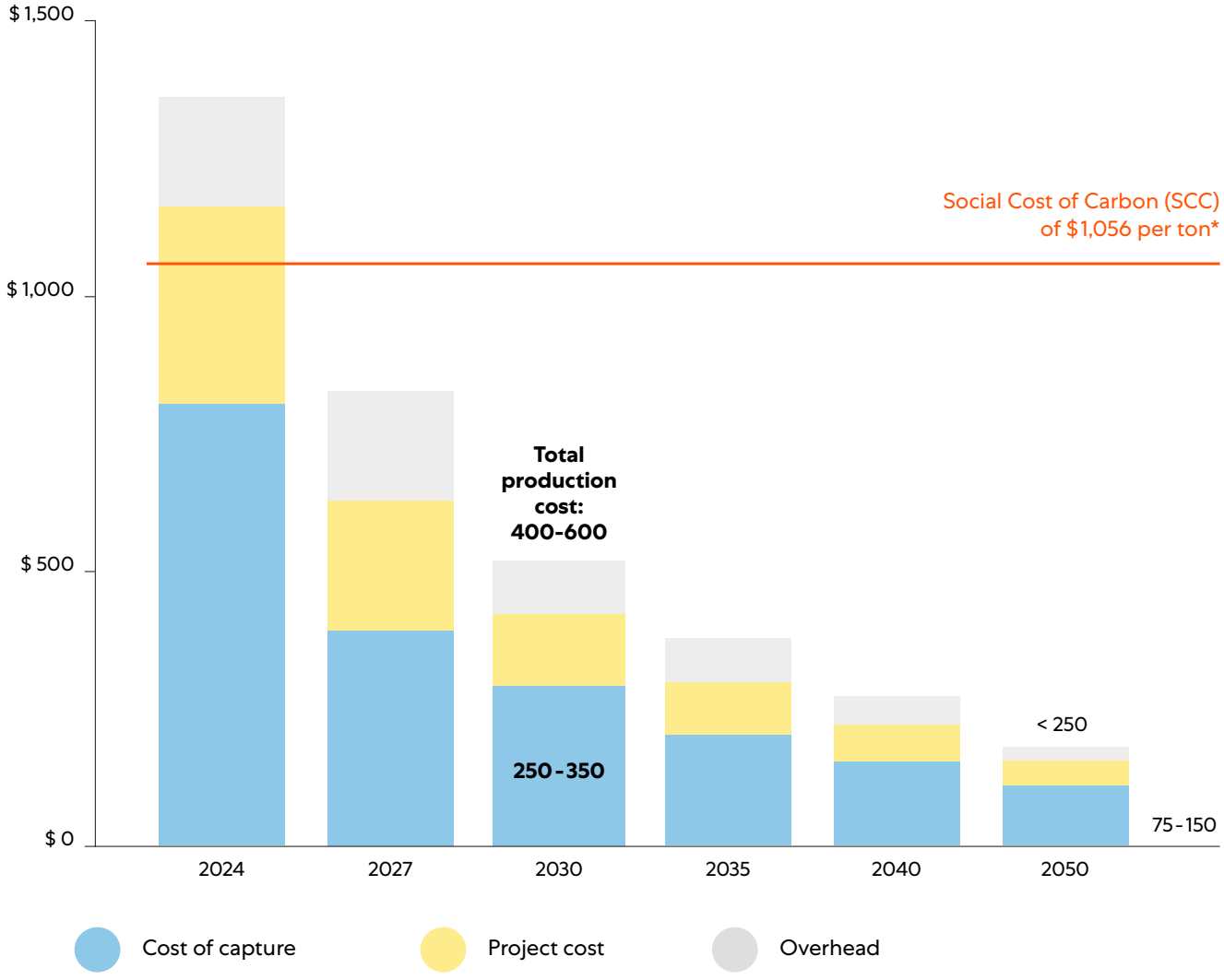
2. Low carbon energy is crucial to scale up carbon removal

Renewable power is crucial; direct air capture plants can be located where such energy is available.

3. Carbon removal is expected to become more economical, making it a viable solution for addressing climate change

The whole carbon removal industry is aiming to reduce costs significantly by 2050. Climeworks has concrete plans to reduce the current cost of **$1000** per ton to **$250 to $350** by 2030 and further down to **$75 to $150** by 2050.

The social cost of carbon, which represents the cost society bears for emitting an additional ton of CO_2, is estimated to be just over $1000. This implies that even at current costs, it is more economical for humanity to operate Direct Air Capture plants than not to.



* Adrien Bilal and Diego R. Känzig: The Macroeconomic Impact of Climate Change Global vs. Local Temperature. NBER Working Paper No. 32450 May 2024

4. Technology drives the innovation needed to reduce costs and energy consumption

Innovative technologies in carbon removal enable the development of efficient processes and materials that can capture CO_2 faster and with greater capacity thus making the removal of gigatons of CO_2 economically viable and sustainable.

Innovations like Climeworks' third-generation technology promise to double CO_2 capture and halve costs, aiming for gigaton-scale removal.

Focus on the breakthrough in Direct Air Capture: Climeworks Generation 3 plants

Generation 3 technology by Climeworks increases the efficiency of CO_2 capture, reduces energy usage, and lowers costs. This new technology incorporates advanced materials and processes that enhance the capture rate and durability of the equipment, ensuring long-term sustainability and reliability.

The Generation 3 direct air capture technology is based on novel structured sorbent materials housed in modular cubes.

It represents a major milestone in Climeworks' cost reduction strategy, which aims to achieve costs of $250-350 per ton captured and total costs of $400-600 per ton net removal by 2030. This represents an overall cost reduction of up to 50% compared to today.

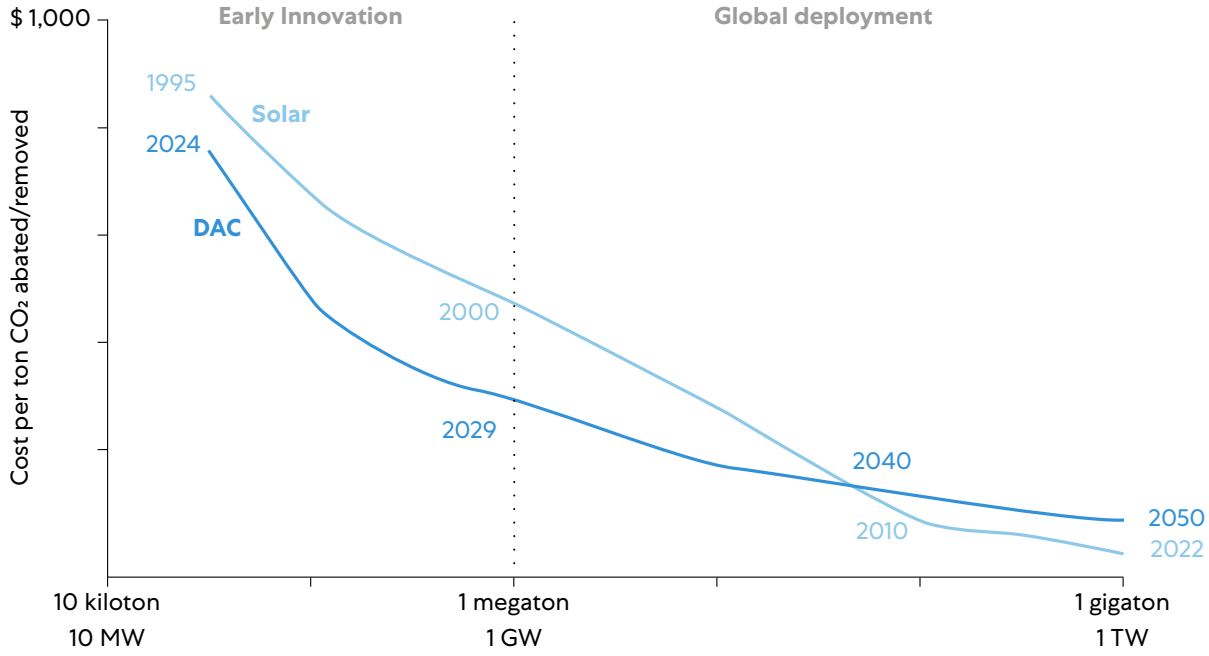
Read more here

3D renderings of Generation 3 technology Climeworks containers

5. An ecosystem collaboration is the key to scaling carbon dioxide removal from millions to billions of tons

Only an ecosystem collaboration with offtake agreements, policy support, public procurement, and investment in infrastructure will unlock scaling carbon removal to gigaton levels.

Actual 2020 solar capacity was **20x higher** than forecasted in 2005 and **120x higher** than forecasted in 2000. **It is up to all of us to make this success happen, the time is now to make the next step together.**



"No one could solve the sustainability challenge alone. It is an ecosystem challenge. We can only make it happen together."

Sebastian Kaczinsky, Chief Sustainability Officer, SAP Switzerland

3 Policies must drive demand for carbon removal to reach the scale needed

"There is not a single IPCC model deemed credible that suggests that we can meet our temperature goals without some degree of negative emissions."

Kaya Axelsson
Head of Policy and Partnerships Oxford Net Zero

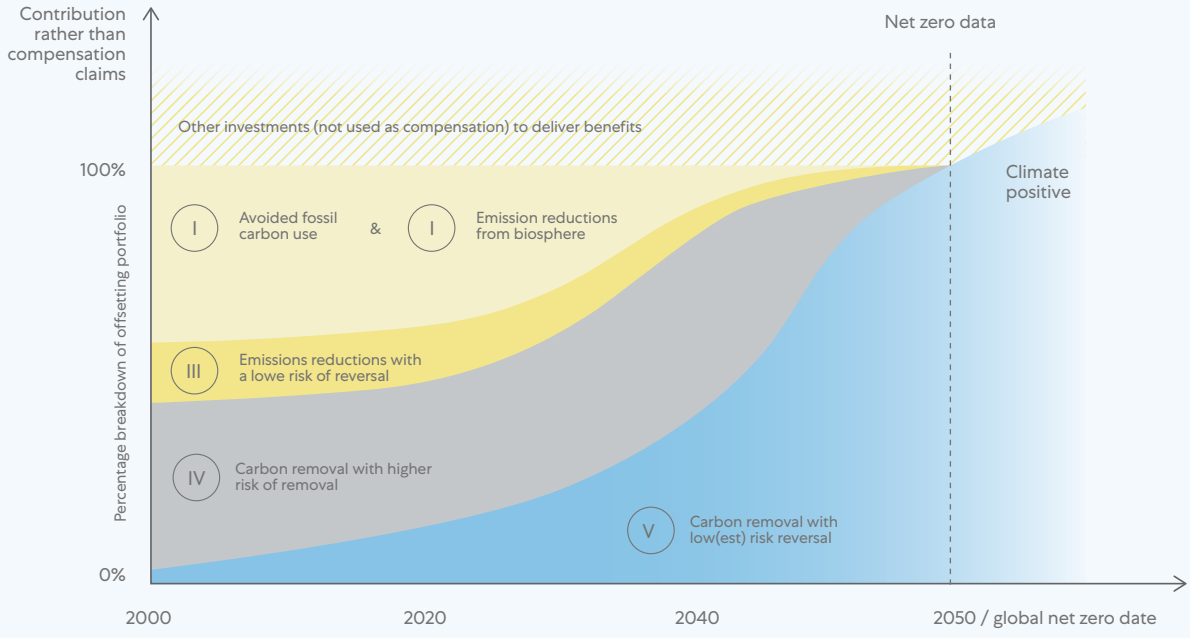
Key messages of the second edition of the State of Carbon Dioxide Removal (CDR) report published in June 2024:

- Limiting warming to 1.5°C or well below 2°C requires rapid and deep emission reductions and near-term scale-up of CDR (from 2.2 gigaton in 2023 to 7 to 9 gigaton p.a. by 2050)
- To scale up CDR and increase CDR innovation and scale-up, we need policies to create demand as well as a robust Measurement Reporting and Verification (MRV), for a broad portfolio of CDR methods.
- There is a gap between the amount of CDR in scenarios that meet the Paris temperature goal and the amount of CDR in national proposals.

Across IPCC scenarios there is agreement on the need for removals. Durable carbon removal will need to be scaled 30-fold by 2030 and one-thousand-fold by 2050 under IPCC scenarios aligned with the Paris Agreement.

The Oxford Principles for Net Zero Aligned Carbon Offsetting (the "Oxford Offsetting Principles") outline how offsetting needs to be approached to help achieve a net zero society. The four principles are:

1. Prioritize in-house reductions and only use high-integrity credits. Work simultaneously on reduction and removal efforts, rather than in sequential approaches
2. Shift toward carbon removal approaches. "Most credits in the voluntary market today are associated with emission reductions or avoided emissions. Organizations must shift towards carbon removals, which remove carbon from the atmosphere to counterbalance residual emissions and achieve net zero."
3. Shift towards removals with a low risk of reversal (durable carbon removal)
4. Support the development of innovative and integrated approaches for achieving net zero



The necessity for carbon removal is evident. To generate demand for at the gigaton scale, which is essential to meet the Paris Agreement goals, robust incentives and policies are required. Policymakers have begun setting CDR targets. For instance, in Europe:

- The EU 2040 targets establish clear CDR volume goals for the region.
- Both the EU and the UK are progressing towards incorporating CDR into their Emissions Trading Systems (ETS).
- The Carbon Removals and Carbon Farming (CRCF) framework sets the stage for using durable CDR to offset fossil emissions.
- Governments, such as Denmark, are developing systems for large-scale public procurement of CDR and implementing additional policies to stimulate demand, like the Green Claims Directive.

"We need to be putting in place active measures to scale and innovate the types of solutions that are going to store carbon over the long-time frames."

Kaya Axelsson
Head of Policy and Partnerships Oxford Net Zero

"The successful scaling of green solutions is achieved through the collaborative efforts of individuals, companies, well-designed policies, supportive government, and technological advancements."

Dr. Akshat Rathi
Senior reporter for Climate, Bloomberg Green, Author of "Climate Capitalism"

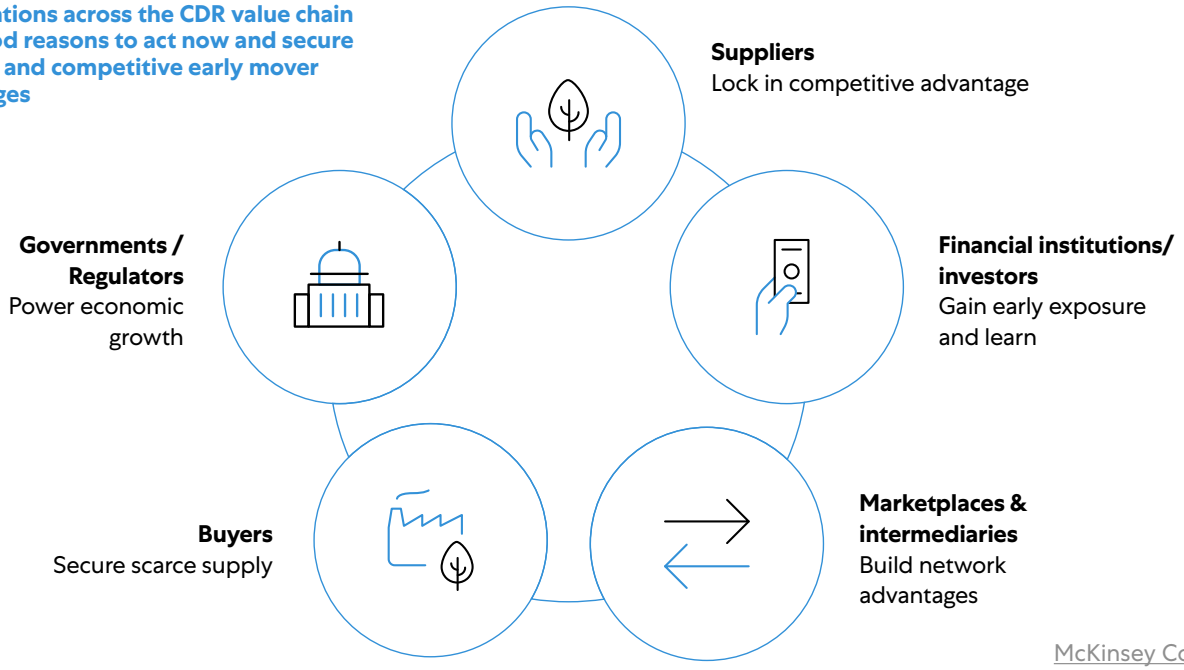
4 Being an early mover in carbon removal offers significant advantages

Delivering 6 to 10 gigatons of carbon removals could create an industry worth $0.3 trillion to $1.2 trillion annually by 2050.

"The time to invest in carbon removal is now. Climate change is not waiting, and neither can we. Why act now? For governments, the CDR industry can power economic growth. For suppliers, lock-in competitive advantage. For financial institutions and investors, it is a way to gain early exposure and learn. For buyers, it is a way to secure scarce supply."

Emma Parry
McKinsey Partner, Global co-leader of Carbon Management service line

Organizations across the CDR value chain have good reasons to act now and secure strategic and competitive early mover advantages



McKinsey Company

"Early investment in carbon removal technologies can provide significant advantages. Do not wait until it is too late."

Emma Parry
McKinsey Partner, Global co-leader of Carbon Management service line

What are the advantages for buyers of investing early in carbon removal?

1. Securing Supply

Early buyers can secure access to a potentially scarce supply of carbon removal services, ensuring their ability to meet future carbon offset needs.

2. Price Advantage

Engaging early in the market may allow buyers to lock in more favorable prices before demand drives costs up.

3. Strategic Positioning

By investing early, buyers can position themselves as leaders in sustainability and corporate responsibility.

4. Market Influence

Early buyers can influence the development of industry standards and practices, shaping the market to their advantage

"By embedding carbon removal into high-end services, companies can create carbon-neutral or lower-emission products, appealing to environmentally conscious consumers."

Boyo Owolabi
Principal at BCG

5 The future of carbon removal is a portfolio approach: combining efforts to create a greater impact

A carbon removal portfolio approach allows for a diverse and balanced strategy that can address various aspects of the climate crisis holistically. Different companies are developing innovative technologies that complement each other, covering different verticals and parts of the world.

The portfolio approach increases demand and supply, enhances biodiversity, and empowers local communities, leading to a more effective and sustainable carbon removal strategy.

What are all the benefits of a carbon removal portfolio approach for companies?

1. Diversify investment to maximize climate impact

Each CDR technology comes with different advantages and co-benefits.

2. Minimize risks associated with a single solution or supplier

3. Increase flexibility in adapting to changing market conditions

For example, technological advancements, policy changes, and regulatory conditions.

Technology-based removals costs are expected to decline over time, while costs for nature-based removals will increase.

Source McKinsey report Carbon removal: how to scale a new gigaton industry.

4. Match the company's budget and needs

"Addressing climate change effectively requires a holistic perspective that combines technological innovation with natural processes. The future of carbon removal is a portfolio approach. Embracing the concept that the entire planet is an interconnected ecosystem can lead to innovative carbon removal solutions that leverage both technology and the biosphere's natural abilities."

Diego Saez Gil
Pachama

"To help speed and scale the growth and development of carbon dioxide removal (CDR) technologies, JPMorgan has also committed to long-term offtake agreements.

Direct Air Capture removals align well with our principles in terms of being a measurable, additional, and permanent CDR solution."

Hannes Koffler
Managing Director, JP Morgan

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