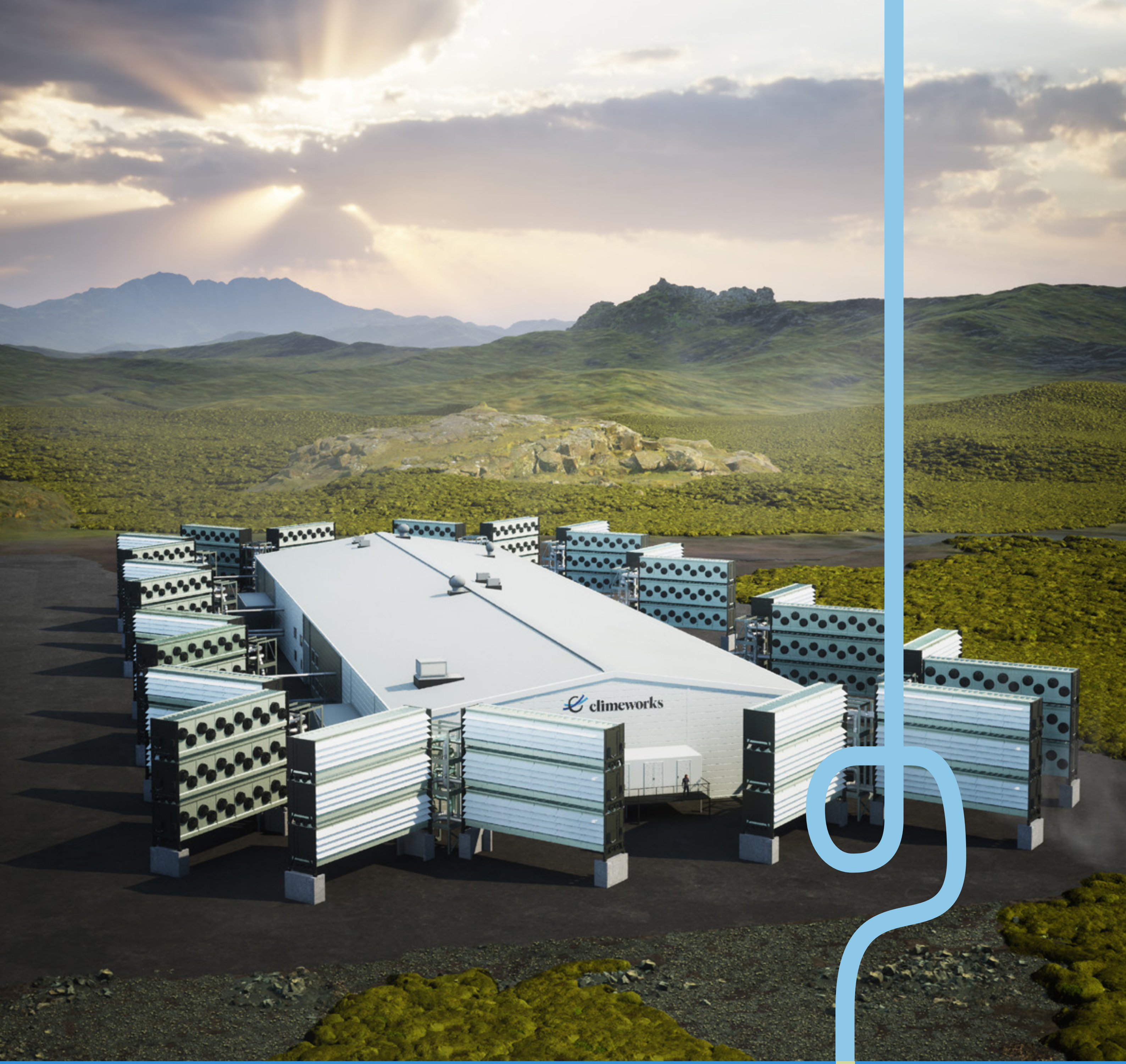


climeworks

Scaling DAC: deployment stage

Industry snapshot

December 2022

Table of contents

Introduction

Welcome to our second DAC industry snapshot

We are delighted to introduce our second industry snapshot, our publication focusing on the trends and topics within the direct air capture (DAC) industry. In this iteration, we examine how deployment of DAC enables further industry scale-up.

Deployment is the phase following successful in-lab development and real-life demonstration. It is a crucial part of the DAC+S scale-up journey, which involves participation and input from a wide array of stakeholders. At Climeworks, deployment began over half a decade ago, with our first plants put into operation in 2017. As different contributors highlight below, time spent in the field is crucial to enabling scaling, and we are no exception here. Having real-time feedback and generating constant insights has served as an inspiration for the main topics discussed here: the respective roles of lab research and field experience, how DAC+S can drive equity, the important role of the voluntary carbon market, and how demand is a key lever in driving supply chain growth.

As deployment continues to roll out on a global scale, it also places increased responsibility on different change drivers: Policy, for instance will play an ever-increasing role in pushing the market to adopt standards furthering high-quality CDR. How policy defines standards and protocols will thus at least partially inform markets and successful climate action steps. Given this, the snapshot will also look at the importance of MRV – measuring, reporting and verification, and how high-quality CDR needs to improve not just from a cost, but also an emissions perspective.

We hope you enjoy reading these reflections.

“One thing is clear – the DAC industry continues to progress rapidly, and deployment is becoming increasingly visible,” says **Christoph Gebald, Co-CEO of Climeworks.** “Given the continued growth of our industry including Climeworks’ upcoming milestones, it will be increasingly important to leverage learnings of various experts and stakeholders, which are playing an ever-increasing role in helping us drive climate positive impact at scale.”

“It is incredibly exciting to see the industry at large coming closer to deployment stage” says **Jan Wurzbacher, Co-CEO of Climeworks.** “In June 2022, we announced the groundbreaking of Mammoth, less than a year after the launch of Orca. While an important step on our 13 years journey as a company, it’s still early days and what matters is ahead.

Based on our own experiences of bringing commercial DAC to life, we know that it takes an ecosystem to deploy successfully. Climeworks is happy to contribute to the permanent CDR community by assembling experts’ views on the most crucial elements required to materialize DAC’s global deployment.”

Scaling DAC: deployment stage

What does deployment stage mean in the case of DAC?

Dr. Carlos Härtel

Chief Technology Officer, Climeworks

The direct air capture industry has been described with words like “nascent” and “burgeoning,” and the latter seems particularly applicable, especially when considering its steadfast growth in recent years. Indeed, direct air capture is entering its deployment stage now, with new, large-scale plants expected to come online across the world alongside a growing market presence.

The deployment stage of direct air capture is the time when first commercial plants begin to be operational “in the real world.” This stage follows successful initial lab-scale R&D and technology validation by prototypes and demonstrators. In terms of market presence, deployment means that commercial plants already attract interest from customers and partners.
From a Climeworks perspective, deployment began with our first direct air capture plant in Hinwil, Switzerland, commissioned in 2017. Over the last years, we have greatly benefited from the learnings it provided and subsequent improvements, resulting in the launch of our first large-scale DAC+S plant, Orca, in September 2021.

With construction on Mammoth, our second plant in Iceland, underway, we will accelerate our global scale-up as well as continue turning insights from real-life operation into improvements of technology and engineering designs.

Scaling DAC: deployment stage

What makes the deployment stage a crucial step of DAC's scale-up journey?

Dr. Carlos Härtel

Chief Technology Officer, Climeworks

> "Most importantly, deployment shows the successful evolution from lab set-ups to large-scale removal capabilities."

Deployment is one of the most crucial steps in the scale-up journey. Indeed, it represents "turning the corner" after R&D and technology validation. Most importantly, it shows the successful evolution from lab setups capturing minute amounts of CO_2, to large-scale removal capabilities that can be further expanded. It is particularly important from a public trust perspective, as it signifies the transition from concept to reality.

Still, first deployment does not mean that a technology is finalized in any sense. Rather, the cycle of progress from field experience to better technology that again goes out to prove itself in the field never stops. Each time, learnings are gathered, which play a crucial role in the further improvement of process efficiencies, operational flexibility, robustness, or costs. If direct air capture is, in fact, "nascent," like any young technology, continuous development over extended periods of time will be necessary to highly optimize everything from sorbent to capture and storage processes.

The next stage in the evolution of technology is maturity. Typically, it is achieved only after a larger number of full-scale plants has been successively put into operation. Continuous improvement still goes on; however, the step changes in plant performance and cost, which are the hallmark of innovation in the earlier phases, give way to more gradual improvements over time. This underscores the importance of the deployment stage: it is the "make it or break it" phase of the direct air capture journey.

> "The deployment stage is the "make it or break it" phase of the direct air capture journey."

Field experience: the essential enabler for progress

From lab to real world

Dr. Mijndert van Spek

Associate Professor at Heriot-Watt University

How can field experience through deployment advance the scale-up of DAC?

The construction of the first series of plants is an exciting time for companies developing new technologies. Companies go through a massive learning on what is needed to make their plant work in real operating environments. Building the first plants also means getting a much better handle on what the real costs are and may be in the future. This is nicely illustrated in the graph on the next page.

When technologies move from basic research and development through demonstration and deployment, the cost estimates for a technology usually go up. Although this may sound counterintuitive, it is really quite logical. When designing the first plant, you want to make sure it will work, while you don't have large-scale operational experience yet that will tell you how your plant will work exactly. To that end, often a larger degree of redundancy or overdesign is applied to the plant design. There may also be unforeseen cost additions related to integrating different parts of a plant or system, that have previously only been demonstrated stand-alone.

Another reason may be that certain parts of the plant (or operating materials) are not yet standardized and need to be custom made, and there may be unforeseen exogenous costs increases too, like regulatory, land, and insurance costs. Finally, the operational costs of first commercial plants are also often higher, because comparatively more personnel is needed to get the first plant running. Likewise, maintenance and troubleshooting costs are higher, and staff needs to be trained if the technology is very different from existing facilities.

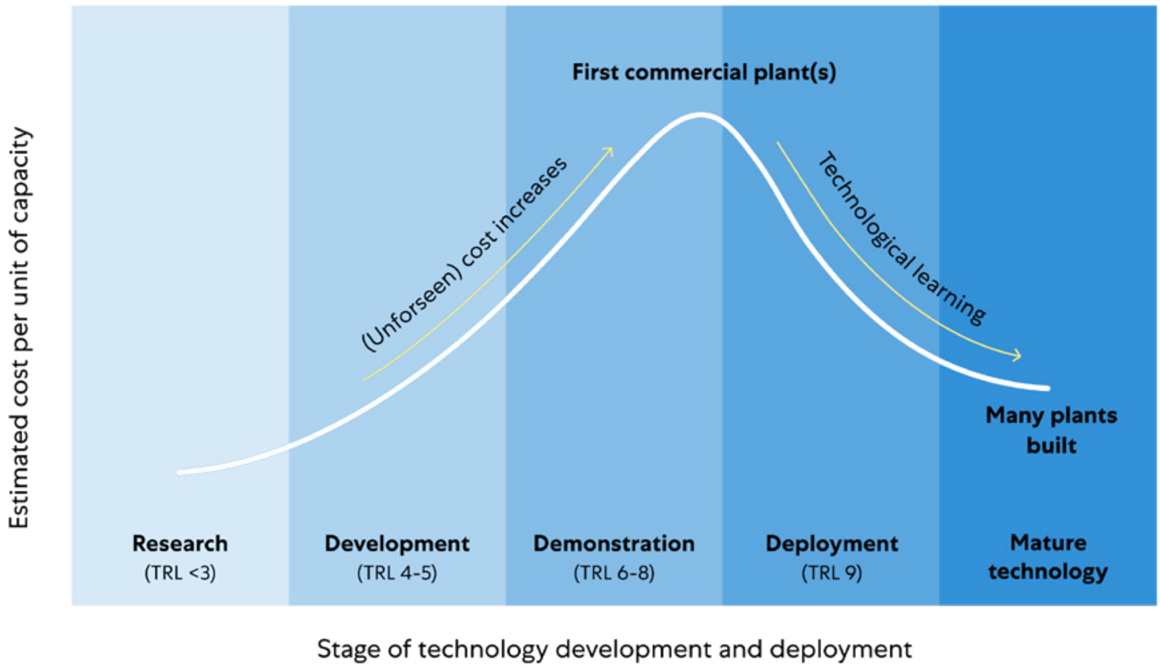
> “The good news is that from the moment you build your first plant(s) onwards, the costs can come down quite quickly. Field experience teaches you which redundancies and overdesigns are really needed.”

Field experience: the essential enabler for progress

From lab to real world

Dr. Mijndert van Spek

Associate Professor at Heriot-Watt University



The good news is that from the moment you build your first plant(s) onwards, the costs can come down quite quickly. Field experience teaches you which redundancies and overdesigns are really needed and which can be removed, which materials withstand the operating conditions best, lowering maintenance cost, and how you can optimize the operation of the plant. As operators become more acquainted with the plant, they often bring good ideas for performance improvement, and which parts of operation can be automated. Higher fidelity in the technology may lower insurance costs and financing costs, which are indirect effects of the field experience obtained (risk costs money!). Finally, the experiences from the field will feed back to the R&D folks, who can use this to develop next generations of improved technologies. The result of all this is that costs come down, fidelity in the technology increases, risk is lowered, and a technology becomes all the more 'investible', paving the way to roll out at large scale.

Field experience: the essential enabler for progress

Learning from other industries

Dr. David Hart

Senior Fellow, Center for Clean Energy Innovation | Information Technology and Innovation Foundation

"Grid-scale energy storage provides an example. Field experience has revealed insights into siting, operation, and management that are of value to regulators and system operators as well as to the industry."

What role does gaining field experience play in the early stages of an emerging industry?

Industry creation and growth is a multi-faceted process. The maturation of a new industry's core technology is necessary, but not sufficient, to drive it. The old saying "build a better mousetrap and the world will beat a path to your door" is misleading. Without field experience, no one will pay attention and, indeed, the technology will not even mature.

The field setting differs from the lab setting in many ways. The scale is larger, the context is less controlled, and many more actors are involved. These differences produce vital forms of knowledge that cannot be gleaned from lab work.

Scale matters because many systems, especially complex systems, perform differently when they are scaled-up. New failure modes may emerge along with unanticipated opportunities for performance improvements or cost savings. Field experience allows businesses in emerging industries to discover and manage the risks and to capitalize on the benefits. The wind industry exemplifies this point. Learnings through experience about wind farm siting, configuration, and operations, for example, have improved capacity factors and reduced costs over time.

Field experience: the essential enabler for progress

Learning from other industries

Dr. David Hart

Senior Fellow, Center for Clean Energy Innovation |
Information Technology and Innovation Foundation

Systems in the field must satisfy end-users, typically paying customers, who want to derive value from them. Often that value is not well-understood by the emerging industry until end-users explain it. Once the end-user's value proposition is understood, systems may need to be tweaked or even overhauled to fulfill it. Grid-scale energy storage provides an example. Its value is time-and-location-specific, and the same system often has the potential to provide multiple services. Field experience has revealed insights into siting, operation, and management that are of value to regulators and system operators as well as to the industry.

Field experience also allows emerging industries to gain a social license to operate. Workers, communities, and regulators are some of the actors who might raise an emerging industry's costs of doing business or even obstruct its activities. The industry must, at a minimum, learn how to communicate effectively with such actors and, frequently, must adjust its practices to win their acceptance. The nuclear power industry is one that has struggled with this challenge. Field experience in some places enabled its expansion as public confidence grew, while in others, societal resistance to nuclear plants grew over time, blocking further development.

Field experience that allows emerging industries to solve technical problems at scale, understand how to provide value to end-users, and gain societal support builds confidence among investors. A project or company's bankability depends on predictably reducing risks and securing revenue streams. Investors may also find psychological reassurance beyond the numbers when they see new technologies in practice in the field.

The nature of the knowledge gleaned from field experience and its precise value vary greatly from one industry to another. Some industries may require just a few field installations at scale to gain investor confidence, while others may need many installations in a variety of different contexts. But the bottom line is consistent: field experience is essential to any emerging industry's continued development and ultimate success.

Driving fast learnings with high integrity and quality

MRV: first perspective

Dr. Stephanie Arcusa

Postdoctoral researcher, Center for Negative Carbon Emissions - Arizona State University

What does monitoring, reporting, and verification (MRV) refer to in the context of the DAC and CDR industry?

Measurement, reporting, and verification (MRV) refer to the multi-step process of measuring carbon removal and reporting these measurements to the relevant third party. The third party then verifies the reporting so the removal can be certified. Monitoring is an additional step in this process because removed carbon must stay stored at least for the commitment period and in perpetuity for climate mitigation. The responsible party must monitor the stored carbon to remediate potential releases. A more complete descriptor of the process is MMRV – measurement, monitoring, reporting, and verification.

For DAC, MMRV has a different meaning. DAC operators are subject to providing measurements of air CO_2 capture and monitoring if they meet the standards (e.g., equipment and methodology specifications). The operators may report to the relevant parties (e.g., the storage partner and certification organization). Third-party auditors may check the carbon source and verify the reported measurements.

For CDR or DAC, standards encode the process of MMRV through methodologies for measurement and monitoring and procedures for reporting and verifying. Standards play a critical role in building trust that activities are performing as expected. Whether the standards are appropriately designed is a separate question, which must be constantly evaluated against the task at hand – mitigating climate change. Standards must be designed to prove performance, as in any other industry.

Why is MRV important for the deployment of DAC?

DAC plays two roles in climate mitigation. First, it offers the possibility to close the carbon loop by providing air carbon to convert to fuel or other short-lived products that will displace fossil carbon. Second, when combined with storage for CDR, it offers the possibility to neutralize emissions. In either case, DAC must prove to the public, critics, and investors that it is performing as intended. Standards used for certification will encode that evidence. It is to the benefit of the DAC industry's credibility to push for high standards.

High standards will be our only safety net as the industry scales from initial deployment to a point where we can observe a difference in the concentration of CO_2 in the atmosphere. A potential failure of CDR will not be immediately evident. Standards instituted today will set the tone for decades to come, with difficulty in changing course. It is, therefore, critical to set high standards today for the criteria that matter the most – accounting and durability – with the option to increase the stringency of the measurement accuracy as the technology improves.

Driving fast learnings with high integrity and quality

MRV: second perspective

Anu Khan

Deputy director of Science & Innovation, Carbon180

What does monitoring, reporting, and verification (MRV) refer to in the context of the DAC and CDR industry?

MRV is the process of tallying up all the emissions, energy use, and broader effects – intentional or unintentional – associated with a carbon removal project, to determine its net impact.

Breaking it down:

- Monitoring is the measurement of carbon removal activities and outcomes over time to determine whether the carbon that was removed from the atmosphere stays safely and permanently locked away.
- Reporting is a full picture of a carbon removal project, including tons removed, energy consumption, public safety metrics, and ecosystem impacts.
- Verification is the process of ensuring that each ton removed has a real climate benefit, reducing the risk of fraud and underpinning each carbon removal transaction.

All together, MRV tells us if the work was done safely and effectively, and provides receipts.

Why is MRV important for the scale-up of DAC?

At Carbon180, we believe that robust MRV is a fundamental prerequisite to build trust in the carbon removal sector and scale these technologies.

MRV demonstrates to local communities and the general public that climate-beneficial activities took place and carbon was removed from the atmosphere. It enables accountability, if promised benefits are not delivered. Accountability in turn builds trust. That trust unlocks the investment of societal resources — capital, energy, human resources, and political will — necessary to achieve gigaton scale by 2050. Over time, robust MRV practices minimize fraud and maximize public benefit, maintaining public trust in the CDR sector for the long haul.

For MRV to enable accountability and build trust, four things must happen:

1. Direct accounting of removals, public health, and environmental impacts using observational data as much as possible.
2. Traceability of both carbon storage and broader impacts over time. Impacts do not end when a project ends on paper.
3. Transparent and accessible reporting of project-related data.
4. Verification of project-activities using an open-source, peer-reviewed protocol, conducted by a financially independent third-party.

We call this High-Accountability MRV and it describes our vision for what MRV could look like in the long run. Defining these guiding principles now means we can identify and develop policies needed to improve carbon removal technologies and MRV protocols together — ensuring that the industry is built on pillars of both trust and scalability.

Driving fast learnings with high integrity and quality

Environmental & social justice

Dr. Simone H. Stewart

Industrial policy specialist for Climate and Energy Policy, National Wildlife Federation

How can DAC contribute to environmental and social justice when scaling up?

As DAC technologies scale up, both domestically and internationally, the industry has a real opportunity to invest in environmental and social justice by meeting the needs of different communities and acknowledging their different truths, while also enacting the fundamental principles of doing no harm and not exacerbating existing harms.

Before exploring how DAC can contribute to justice, it is most important to understand the causes and ramifications of injustice in communities. This responsibility, though seemingly outside the purview of many in the DAC ecosystem, belongs to everyone who hopes to see DAC scale as a successful climate solution. Perhaps it is not possible for DAC to remedy all historic harms that have been perpetuated against marginalized communities, but without recognition that the climate crisis disproportionately affects Black, Latinx, Indigenous and other communities of color—the same communities that are often confronting systemic racism, generational poverty, and lack of access to transformative resources—any attempt to enact justice will be inadequate.

In the international context, DAC is often cited as a "great equalizer"—the Global North that has largely been responsible for producing the emissions which have led to the current crisis, can deploy this technology to remove legacy emissions from the atmosphere, thus freeing up some of the burden on the Global South, especially as many countries transition away from fossil fuels. In this same lens, many view technology-sharing between the Global North and South as a sort of "climate reparations." While these scenarios may be viewpoints of the industry, it is important to both confront the legacy of the Global North's emissions with DAC, but also act immediately on the reality many countries of the Global South face at present, including the destabilization of democracy, famine, and rising sea levels that threaten infrastructure. To truly address "climate reparations" it is vital that the industry analyze historic colonial practices, especially those around sharing resources, and seek genuinely to help enfranchise nations and promote the building of their own sustainable solutions.

Fundamentally every DAC project and the development of the carbon dioxide removal ecosystem, has the capability to prioritize and address the needs of the communities in which the technology will live. As a relatively new industry, in a growing sector, we should outline democratic principles to guide the deployment of these solutions to separate good actors from bad and to co-create the process with communities to ensure they are truly reaping the benefits whether at home or abroad.

Perspectives from demand & supply

Demand: the voluntary carbon market

Stacy Kauk

Head of Sustainability, Shopify

The voluntary carbon market has become a key driver of demand for CDR via direct air capture & storage – supporting the technology's deployment. Why and how?

The difference between distraction and action has driven the voluntary carbon market toward carbon dioxide removal (CDR).

Don't get me wrong – it's not that everything outside of CDR is a distraction. Reducing future emissions, for example, is as important as removing past emissions. The problem is, a net-zero infrastructure is decades away. And as we crawl toward a decarbonized future – and I do mean crawl, given how many coal plants are scheduled to come online over the coming years – good intentions often slide down the slippery slope of distraction.

This is roughly how corporate action looks today: Develop a reductions plan, get it validated, commit to disclosing emissions data. And in the meantime maybe buy some offsets. It's better than nothing, sure, but it distracts us from action – or worse, passes as adequate action. Which is unfortunate because we just don't have time.

The urgency of climate change has inspired a new wave of companies using the voluntary carbon market to kickstart CDR. This movement is a manifestation of pent-up energy from folks who don't want to wait – count me and my colleagues at Shopify among this group.

By its very nature, the voluntary market has a strong bias toward action: It is made up of companies who are volunteering to act. However, in its current state, the voluntary market lacks trust and, all too often, serves as a get-out-of-jail-free card. By starting to voluntarily buy carbon removal, companies are orienting toward solutions that promise to deliver meaningful climate benefits.

To be sure, there is no shortage of distraction around direct air capture. That it's too expensive, or takes too much energy, or won't scale. Buying into these arguments is succumbing to distraction, whereas supporting emerging technologies is believing in action. We'll take action every time, thanks.

Especially when that action delivers results. Orca, after all, is up and running. Mammoth is being built. And the next generation of CDR technologies is busting out of labs around the world. (If you want examples, look no further than our Shopify Sustainability Fund partners). There are very real obstacles ahead of us. The race to lower costs has certainly gotten more complicated with inflation, and the flood of carbon removal buyers that we expected to materialize is still more of a trickle. We understand the challenges. We're just not going to be distracted by them.

Perspectives from demand & supply

Supply: building a supply chain for DAC

Prof. Dr. Greg Nemet

Professor at the University of Wisconsin–Madison in the La Follette School of Public Affairs

“Developing a gigaton-scale DAC supply chain is a monumental challenge but is manageable and can be overcome, especially with policy-supported development of expectations that the market for DAC is large and growing.”

DAC is an emerging industry. What are the challenges associated with building a supply chain for DAC?

Scaling up direct air capture sufficiently to be climate-relevant will be a massive undertaking. Among the challenges is developing a new supply chain for an industry that so far has existed at only a nascent scale. The supply chain for DAC spans the life cycle from materials to energy, to equipment, to expertise, to long term storage of CO_2 and to end of life re-use for equipment. Perhaps counter-intuitively, evidence from the development of supply chains for other sustainability technologies shows that expectations of growing demand are crucial for developing supply chains.

First, developing a global supply chain will require development of a reliable set of input materials and components. Of prime importance will be supplies of clean low-cost energy inputs for heat and electricity. For this, the DAC industry can rely fully on the clean energy supply technologies that have emerged and fallen in cost such as renewables. A bigger effort will be development of a more specialized supply of contactors and adsorbent materials. Service for recycling of sorbents and contactors will be crucial. Offtake infrastructure, specifically compressors, pipelines, injection wells and monitoring equipment will need to develop in step with capture development and requires a build-out akin to the scale we have seen in the natural gas industry over the past half century.

Perspectives from demand & supply

Supply: building a supply chain for DAC

Prof. Dr. Greg Nemet

Professor at the University of Wisconsin–Madison in the La Follette School of Public Affairs

Second, experience with other technologies shows that the modular aspect of low-temperature DAC has the distinct advantages of being adopted more quickly and learning more quickly. This is likely in large part due to the massive numbers of iterations involved. We can think in terms of hundreds of thousands of capture units and into the millions for contactors. This provides opportunities for iterative improvements and introduction of improved technical components. From a supply chain perspective, it also enables the development of specialized production equipment. Development of high throughput, reliable equipment has been crucial in lithium-ion batteries and solar and would expect the same with components for DAC.

Third, while not traditionally a supply chain component, human expertise will be essential to scaling up the industry. This will involve trained scientist and engineers as well as other skills such as construction, marketing, and other skills deployed throughout the supply chain. Human capital is essential to enabling the supply chain to develop and grow. People need to feel that the industry has a place for them, that retraining is worthwhile, and for the young, that orienting their careers to the industry is in line with their values, especially related to sustainability.

Finally, all the supply chain items above depend on expectations that the industry is on a growth trajectory. Shared expectations among stakeholders through the supply chain is crucial to their participation and investment. Analogous technologies show that these expectations can form with niche markets, small markets with relatively high willingness to pay, such as corporate offsets, individual purchases, food and beverage, and other markets for CO_2. Policy plays a key role in enlarging markets, especially when policy support is considered long term and has built in credibility that lowers risk. Mixes of multiple policy components adopted in multiple jurisdictions make demand robust, making the industry resilient to changes in market, social, and technical conditions.

Developing a gigaton-scale DAC supply chain is a monumental challenge but is manageable and can be overcome, especially with policy-supported development of expectations that the market for DAC is large and growing. With that a reliable DAC supply chain will follow.

Contributor biographies

Stephanie Arcusa

Postdoctoral researcher, Center for Negative Carbon Emissions - Arizona State University

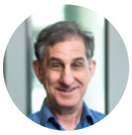
Dr. Stephanie Arcusa is a postdoctoral researcher at the Center for Negative Carbon Emissions at Arizona State University, USA. She is a climate scientist with research interests in climate science policy, carbon accounting, and paleoclimatology. Her current research focuses on advancing the certification of carbon removal, exploring what certification means, how to build trust, and how to guarantee safe, equitable, and successful removal. She is also exploring practical policy ideas for closing the carbon loop and supporting the development of a new carbon economy. Dr. Arcusa received a BSc in Earth Science from the University College of Cork, Ireland, an MSc in Climate Science from the University of Bern, Switzerland, and a doctorate in Climate and Environmental Change from Northern Arizona University, USA.

Carlos Härtel

Chief Technology Officer, Climeworks

Dr.-Ing. Carlos Härtel is Chief Technology Officer at Climeworks AG. He is responsible for shaping the roadmaps for technologies and product designs, ensuring sound execution of the engineering scope for large plant projects, and for collaborating with global R&D partners in the field of sorbent chemistry and process-engineering. Previously, Carlos Härtel was CTO & Chief Innovation Officer for GE Europe. In addition, he served as Director of GE's European Technology Center in Garching near Munich, and as President and CEO of GE Germany & Austria.

Carlos Härtel studied Aerospace Engineering at RWTH Aachen and the Technical University of Munich. He received his doctorate from TU Munich and spent several years in research at the German Aerospace Center (DLR) and at ETH Zurich. He is past-President of the European Industrial Research Management Association (EIRMA).



David Hart

Senior Fellow, Center for Clean Energy Innovation Information Technology and Innovation Foundation

David M. Hart is a senior fellow with ITIF's Center for Clean Energy Innovation and a professor of public policy at George Mason University's Schar School of Policy and Government. He has authored numerous ITIF reports and related publications, including "More and Better" in 2020, "Clean and Competitive" in 2021 and "Climate Innovation Policy from Glasgow to Pittsburgh" in 2022. He co-authored Energizing America (Columbia University Center for Global Energy Policy, 2020) and Unlocking Energy Innovation (MIT Press, 2012). In 2011 and 2012, Hart served as assistant director for innovation policy at the White House Office of Science and Technology Policy, where he focused on advanced manufacturing issues. Hart has written on a wide range of topics in science, technology, and innovation policy. His other books include The Emergence of Entrepreneurship Policy (Cambridge University Press), and Forged Consensus: Science, Technology, and Economic Policy in the U.S., 1929-1953 (Princeton University Press). He earned his Ph.D. in political science from MIT in 1995.

Stacy Kauk

Head of Sustainability, Shopify

Stacy Kauk joined Shopify in January 2020, and as Head of Sustainability, Stacy's role is to ensure the millions of businesses using Shopify's platform, the nearly 600 million shoppers (that purchased from a Shopify merchant last year alone), and climate entrepreneurs globally are working together in the fight against climate change. Stacy leads Shopify's Sustainability Fund, which has committed more than $32 million to date (since 2019) across 22 entrepreneurial, tech-driven companies, to accelerate carbon removal solutions globally. Most recently, she was behind Shopify's decision to build and launch Frontier, an advance market commitment to buy an initial $925M of permanent carbon removal alongside our partners, Stripe, Alphabet, Meta and McKinsey Sustainability.She also serves on the advisory board of the Carbon Management Research Initiative (CaMRI) at Columbia University. Prior to joining Shopify, Stacy was head of the Ozone Layer Protection Program at Environment and Climate Change Canada. Previously, Stacy worked on several chemicals management regulatory initiatives and represented Canada as a member of delegations for the Stockholm Convention and Montreal Protocol. Stacy began her career as a practicing engineer designing environmental protection measures and pollution prevention controls for a variety of industry sectors. She has worked for the City of Ottawa, Morrison Hershfield, and Golder Associates. Stacy holds a Bachelor of Engineering and Masters in Public Administration from Carleton University.

Anu Khan

Deputy director of Science & Innovation, Carbon180

Anu Khan is the deputy director of Science & Innovation at Carbon180, a US federal policy NGO focused exclusively on carbon removal. Anu helps develop equitable and science-based policies to bring carbon removal to gigaton scale and secure a livable future for generations to come. Her work currently focuses on MRV as a tool for achieving more just outcomes in the CDR sector. Before working on carbon removal policy, Anu was a climate grantmaker and academic research scientist. She holds a BA from Princeton and an MS from Caltech, where her research focused on designing novel catalysts for solid oxide fuel cells and thermochemical fuel generation systems.

Gregory Nemet

Professor at the University of Wisconsin–Madison in the La Follette School of Public Affairs

Gregory Nemet is a Professor at the University of Wisconsin–Madison in the La Follette School of Public Affairs. He teaches courses in policy analysis, energy systems, and international environmental policy. Nemet's research focuses on understanding the process of technological change and the ways in which public policy can affect it. He received his doctorate in energy and resources from the University of California, Berkeley. His A.B. is in geography and economics from Dartmouth College. He received an Andrew Carnegie Fellowship in 2017 and used it to write a book on how solar PV provides lessons for the development of other low-carbon technologies: "How Solar Energy Became Cheap: A Model for Low-Carbon Innovation" (Routledge 2019). He was awarded the inaugural World Citizen Prize in Environmental Performance by APPAM in 2019. He is currently a Lead Author for the Intergovernmental Panel on Climate Change's 6th Assessment Report.

Simone H. Stewart

Industrial policy specialist for Climate and Energy Policy, National Wildlife Federation

Simone H. Stewart is the industrial policy specialist for Climate and Energy Policy at the National Wildlife Federation, working on carbon capture, utilization, and storage, carbon dioxide removal technologies, and other strategies to decarbonize difficult-to-abate sectors like industry. Simone joined NWF in 2021 after receiving her Ph.D. in Mechanical Engineering from the University of California Santa Barbara, where she was a National Science Foundation Graduate Research Fellow and the graduate assistant for the Blum Center on Poverty, Inequality, and Democracy.

Mijndert van der Spek

Associate Professor, Heriot-Watt University

Mijndert van der Spek is an Associate Professor at Heriot-Watt University with a track record in process design and optimization of CCS, CCU and DAC technologies and systems, using process simulation, techno-economic assessment and advanced uncertainty analysis to inform decision making on the feasibility of technologies and processes. He is the principal or co-investigator on several UK and EU funded research projects, the vice-chair of the EU networking Action TrANsMIT, Associate Editor for the journal Frontiers in Climate and member of the IEAGHG Cost Network where he led activities on new guidelines for technoeconomic assessment.

Climeworks AG
Birchstrasse 155 CH-8050 Zurich
www.climeworks.com
+41 (0)44 533 29 99
contact@climeworks.com