How to Kick-Start the Carbon Removal Market:

Shopify's Playbook

shopify

1. Introduction

Shopify spent the past year kick-starting the carbon removal market. Our greatest takeaway is that more companies need to demonstrate demand to accelerate market growth.

We're opening up our notebooks to share how we're kick-starting the carbon removal market.

We've figured out a successful approach to support this developing field, and we want to make it as easy as possible for other companies to follow our lead, avoid our failures, capitalize on our learnings, and build on our successes.

If you or your company is looking to buy carbon removal and contribute to a net zero future, you need to:

Fund the right types of climate solutions. We'll walk you through the importance of supporting long-term atmospheric carbon removal, explain why we aren't picking winning industries yet, and share why Shopify hasn't set a net zero target date.

Be flexible with purchases to maximize impact on companies. We'll discuss why it's critical for buyers to be flexible with their purchases—paying higher prices as early adopters of high-quality removal, prepaying, and entering into long-term agreements.

Run a strong process to identify the most promising companies. We'll explain our decision to run a targeted process, share how we evaluate companies and assess performance for investment, and open-source our research, recommendation / decision, and company performance templates.

For companies without the time or resources to conduct a process of your own: we hope sharing Shopify's process will give you the confidence you need to support some of the same companies we have identified.

While our primary audience is companies looking to purchase carbon removal, we expect this playbook to also be useful for climate entrepreneurs, researchers and scientists, and venture capital firms participating in this space.

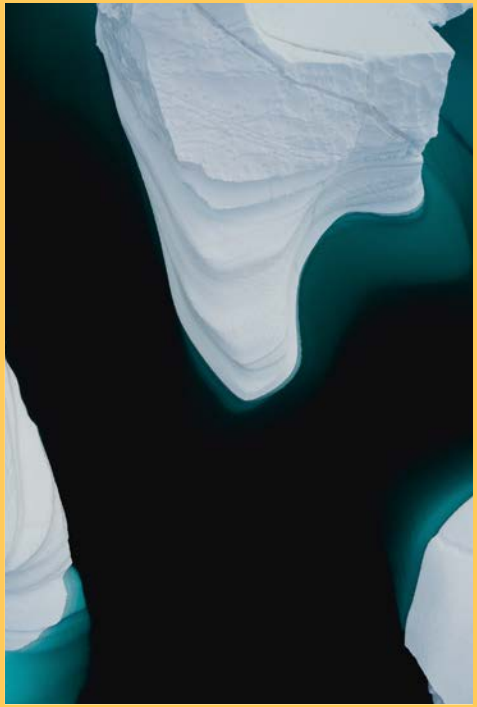
→ *We want your feedback. Get in touch with us at environment@shopify.com and let us know how we can iterate on our approach to increase the impact of Shopify's Sustainability Fund.*

→ *This is a snapshot of year one for our fund. To follow along with updates and content, subscribe to our newsletter or visit our website.*

2. Background

A look back on Shopify's Sustainability Fund launch and how we spent our first year's budget.

A. The landscape in September 2019



Late in 2019, the world was focused on being carbon neutral, but the noise was starting: we need to do more than maintain the current level of emissions in the atmosphere; we have to undo the last 200 years of emissions. Research was progressing and prototypes were being built. The tools were identified but there was a lack of available capital to support the development of frontier technologies.

Companies were working to adopt *science-based targets*, focused on footprint measurement and developing emissions-reduction strategies, with plans to offset all remaining unavoidable emissions. While methodical and important, this alone will not achieve the Intergovernmental Panel on Climate Change (IPCC)'s target of *limiting global warming to 1.5°C*.

There was a missing component: we need carbon removal solutions that work on shorter timescales than nature-based solutions. Shopify CEO Tobi Lütke recognized this deficiency and launched Shopify's Sustainability Fund to solve the problem.

B. The launch of Shopify's Sustainability Fund

Shopify's Sustainability Fund launched in September 2019, with a mission to support the most promising solutions and technologies fighting climate change globally:

"Shopify is a company that wants to see the next century. To make the next century worth reaching, we need to take better care of our planet.

While Shopify is investing in proven solutions that are already fighting climate change, we are also placing bets on high-potential technologies at the frontier of the carbon removal industry.

Our goal is to help prove, scale, and commercialize climate technology for massive impact in the long term.

Commerce is a powerful vehicle for change. Individuals and businesses making conscious choices can change the world, and Shopify is committed to being an active driver of that change."

Tobi Lütke
Shopify CEO

Our goal was to kickstart the carbon removal market by:

- Generating demand when there previously was none
- Allowing new companies to prove their impact and scale
- Driving down prices for future buyers looking to join us

The fund's budget was set to a minimum of $5M USD annually, with a minimum of $1M USD earmarked for permanent atmospheric carbon sequestration. We chose to operate as a capital expenditure fund, purchasing carbon removal at any price, with our return on investment being an accelerated carbon removal market. And with that, our journey began.

$5
MILLION
invested annually

10
INDUSTRIES
we've identified as high-potential

C. Where we landed in September 2020

Spend by solution type

Ocean
Maximizing the world's largest carbon sink and reducing ocean acidification.

Mineralization
Turning carbon into a mineral that can be stored long term.

Renewable energy
Creating fossil fuel alternatives that cause less pollution and that we can create more of.

Collaboration
Partnering with like-minded organizations looking to reverse climate change.

Soil
Using specific farming techniques that increase soil health and soil carbon.

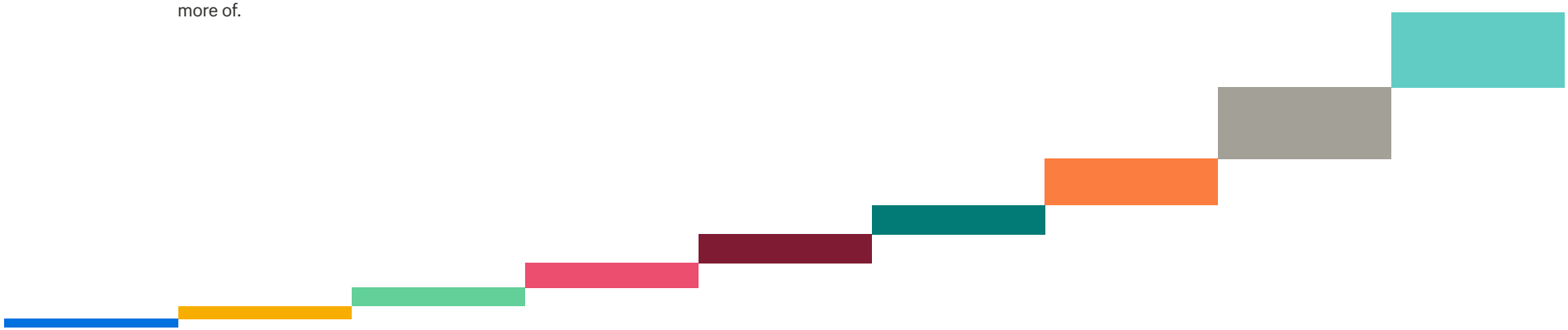
Forest
Planting, restoring, and protecting forests to allow trees to store more carbon.

Transportation
Reducing and offsetting emissions caused by transport vehicles.

Product
Injecting and storing carbon directly into usable products, like concrete.

Direct air capture
Pulling carbon directly out of the air, then storing it safely and long term.

Biomass
Using organic material to create renewable energy and store carbon in creative ways.



3%	4%	6%	8%	9%	9%	15%	23%	24%
Ocean	Mineralization	Renewable energy	Collaboration	Soil	Forest & Transportation	Product	Direct air capture	Biomass

104,800 tonnes*

TOTAL

Our commitments:

Carbofex	1,100	Biomass
Charm Industrial	1,000	Biomass
ECHO2	600	Biomass
Ecoera	1,000	Biomass
Carbon Engineering	10,560	Direct air capture
Climeworks	5,000	Direct air capture
CarbonCure	25,000	Product
Grassroots Carbon	25,000	Soil
Indigo Ag	25,000	Soil
Nori	5,000	Soil
Pachama	80,000	Forest
Planetary Hydrogen	730	Ocean
Running Tide	4,100	Ocean

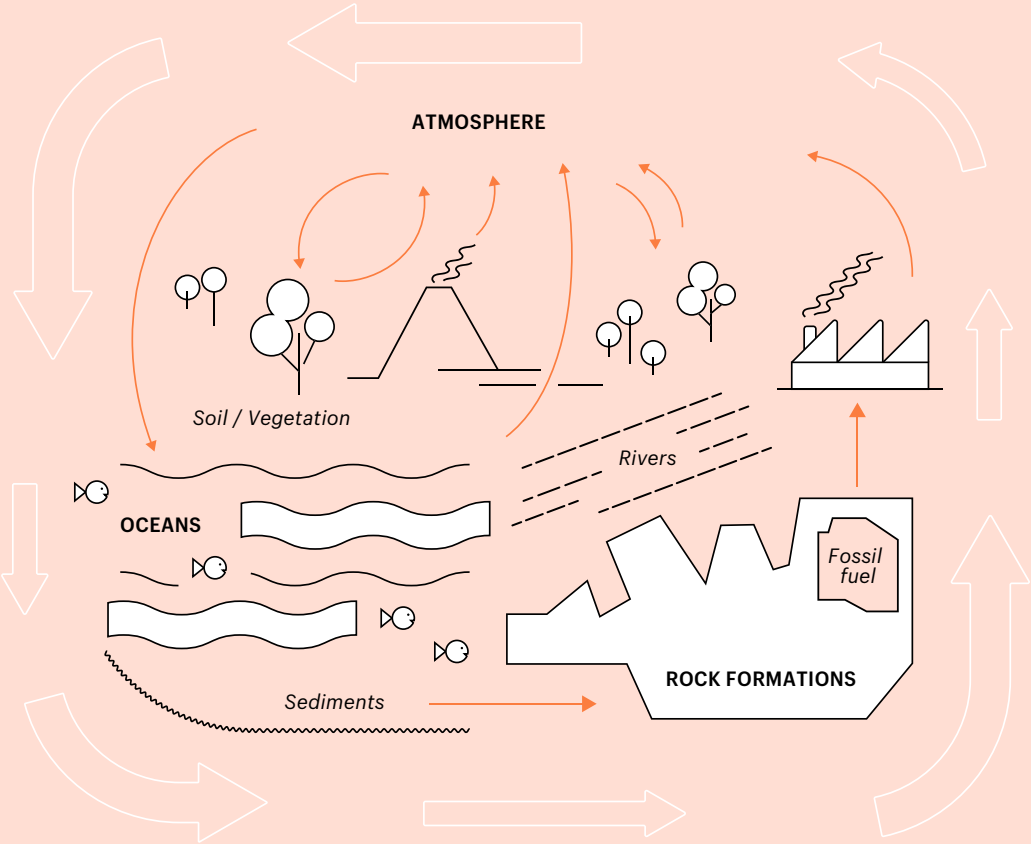
* Quantities represent our total contracted commitment and some tonnage will be delivered in future years.

3. Funding the right types of climate solutions

The key elements and factors we considered when establishing our fund strategy.

A. Long-term atmospheric carbon removal

While reducing emissions is paramount to slowing climate change, we have already increased the concentration of CO_2 in our atmosphere beyond acceptable levels. To reverse these emissions, we must capture CO_2 and store it for the long term outside of the atmosphere.



The IPCC's 1.5ºC report defines *carbon dioxide removal* (CDR) as:

"Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO_2 uptake not directly caused by human activities."

When we set up the fund, there were no solutions that accomplished this at scale. We entered the market to change this narrative, committing at least $1M annually for long-term atmospheric carbon removal. We see atmospheric carbon removal with long-term storage as being fundamentally different from avoided and reduced emissions offsets.

A. Long-term atmospheric carbon removal

I. Atmospheric carbon removal

We are focused on finding technologies and solutions that pull CO_2 out of the atmosphere. This can be accomplished by both engineered and nature-based solutions, including direct air capture, carbon mineralization, sustainable bioenergy with carbon capture and storage (BECCS), ocean-based methods, forests, and soil.

There are a lot of great solutions that reduce or eliminate emissions such as carbon capture utilization and storage (CCUS), energy efficiency, and fuel transition technologies. Heavy industry and large emitting sectors will soon be forced to decarbonize through government policy. Plus, many investors are only willing to finance companies with climate programs that account for their emissions. These two levers will ensure that industrial sectors continue to invest in these kinds of emissions reductions, but on their own will not be enough to reverse climate change.

There is limited incentive for large emitters to fund atmospheric carbon removal and undo more than two centuries of emissions, which creates a funding gap for companies developing these solutions. To solve this, we are leading the charge by creating demand that will drive funding towards atmospheric carbon removal.

A. Long-term atmospheric carbon removal

II. Long-term storage

Duration of carbon storage is a critical factor when evaluating the quality of a technology or solution. It is measured by the number of years a project or solution can keep carbon outside of the atmosphere with a reasonable assurance of it not being re-released.

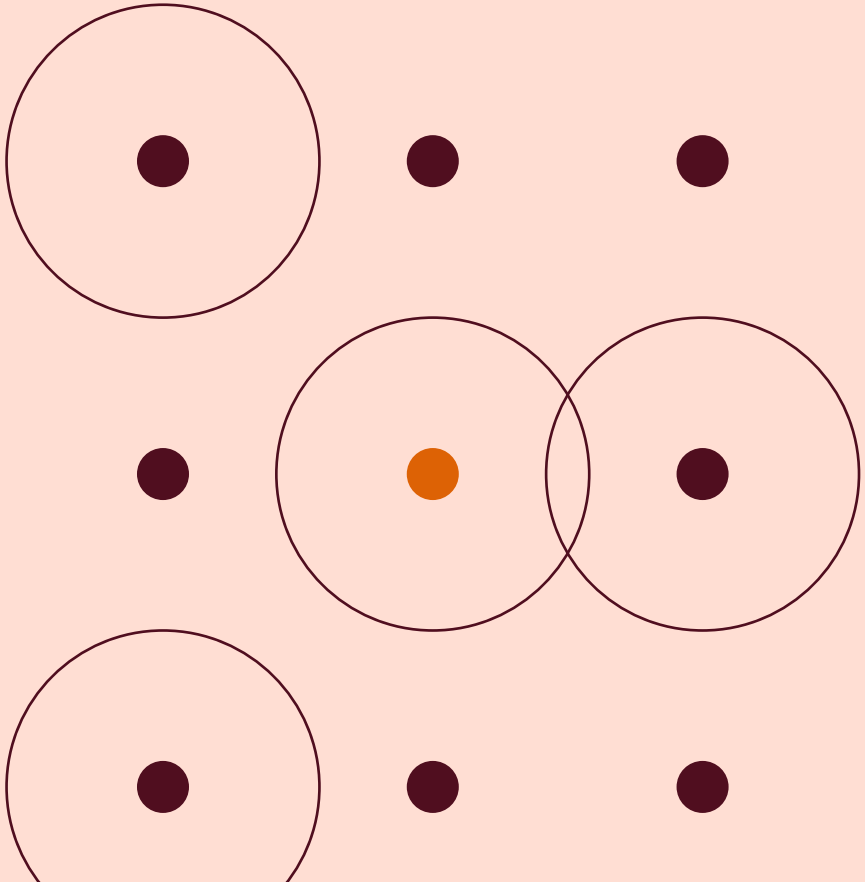
> Our threshold for long-term storage is 100 years or more, as this time horizon will provide the runway needed to develop and implement emissions-reduction measures and carbon removal technologies at scale.

In general, solutions that store CO_2 for longer cost more because they employ emerging engineered technologies, and often require large amounts of clean energy to capture the atmospheric CO_2. Then the captured CO_2 must be safely stored for the long term which again requires technology as well as monitoring and verification systems.

With typical nature-based solutions, carbon is stored for less time since the processes are reversible—when trees die and decompose, for example, much (if not all) of the stored carbon is re-released into the atmosphere. In contrast, many engineered solutions lead to carbon stored for at least 100 years. Some of these engineered solutions accelerate chemical processes that normally take place over many years in nature, including carbon mineralization and ocean alkalinity enhancement; others involve unnatural processes like geologic storage, or reacting and storing CO_2 in the matrix of a long-lived material such as concrete.

A. Long-term atmospheric carbon removal

III. Avoided and reduced emissions offsets



When selecting solutions and technologies, we paid close attention to whether we were buying an avoided emission offset (where CO_2 is prevented from entering the atmosphere), a reduced emission offset (where CO_2 emissions are reduced due to process changes or material substitution), or a carbon removal offset (where CO_2 is pulled out of the atmosphere). While we focused our efforts on carbon removal, we purchased avoided and reduced emissions offsets in a few cases where our purchase would help that technology develop into true carbon removal.

Justin Lazenby of Thomas Concrete stands next to a CarbonCure valve box at a plant in Atlanta, United States

CASE STUDY ⟶ **CarbonCure**

While we focused our efforts on carbon removal, we also purchased avoided and reduced emissions offsets from companies like CarbonCure. The company's mineralization technology enables concrete producers to permanently store captured CO_2 within concrete. The process also increases concrete's compressive strength, reducing the amount of carbon-intensive cement required, which provides additional avoided emissions. Today concrete producers source CO_2 from industrial sources like ethanol production. In the future when CO_2 captured directly from the atmosphere or biogenic sources is more readily available, the technology could easily switch sources. Supporting CO_2 storage solutions like CarbonCure's are a crucial component to scaling carbon removal.

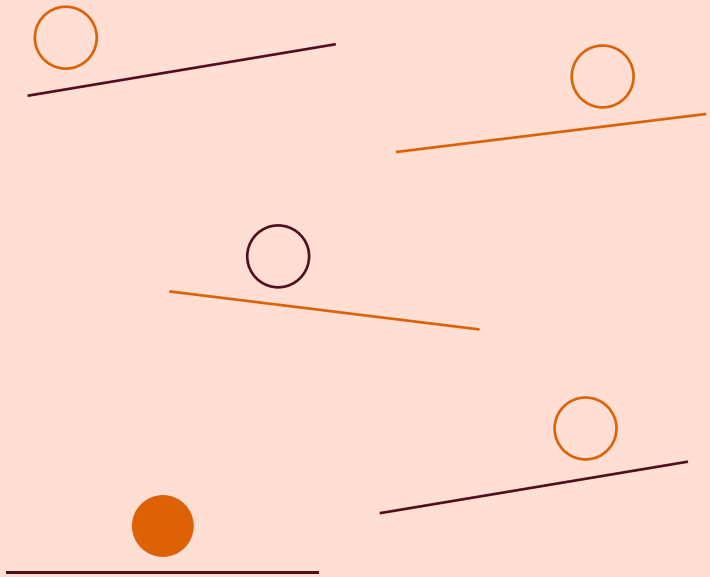
CASE STUDY ⟶ **Pachama**

Nature-based solutions, including forest protection projects like those we support through Pachama, also produce avoided emissions offsets. These are very different from offsets that pay heavy industry to implement process improvements and pollution prevention technologies to reduce their emissions—arguably, heavy industry should already do this and the costs should be reflected in the actual price of the goods they produce. Forest protection efforts provide more than just the climate benefit of avoiding emissions: these projects can have *significant co-benefits* for biodiversity, habitat protection, and community.

B. Building a balanced fund

> We can't wait until the perfect solution is developed and ready to scale; we need to support all kinds of approaches now. We need to get them off paper, out of labs, and into practice. We must accelerate iteration cycles, identify the solutions and technologies that will work and give them access to capital, while learning by doing the entire time.

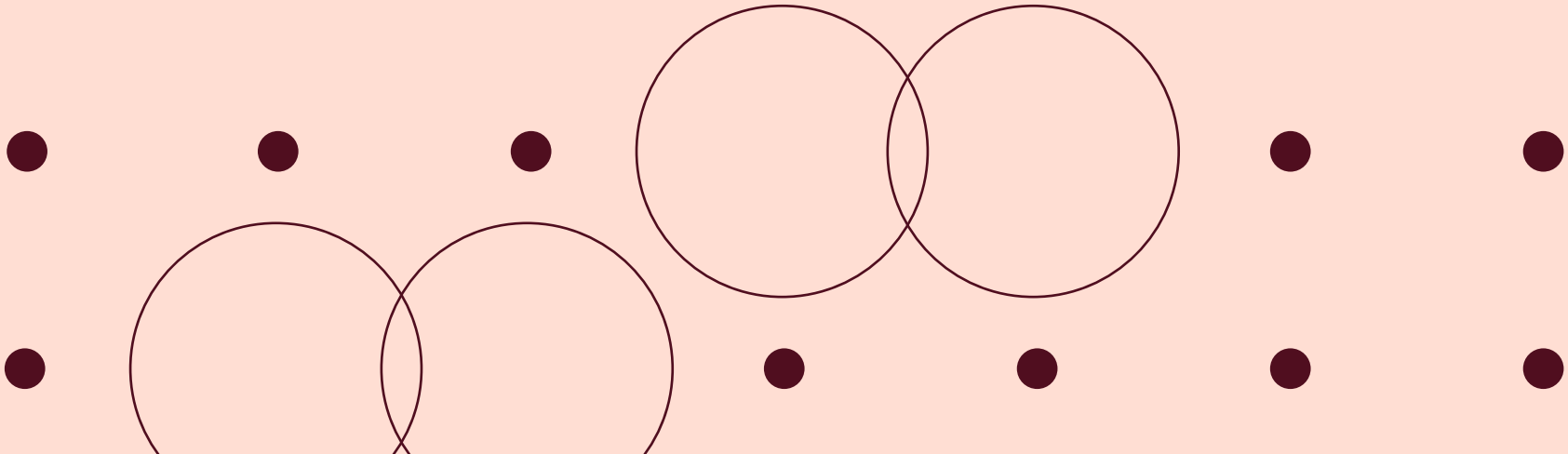
At this point, no one can predict which combination of technologies and solutions will reverse climate change. It certainly won't be one single solution given the sheer amount of CO_2 the world needs to pull from the atmosphere to keep global temperatures below 1.5° C warming: anywhere from *1.3 to 29 gigatonnes per year*. And we don't have a lot of time.



B. Building a balanced fund

I. Engineered and nature-based solutions

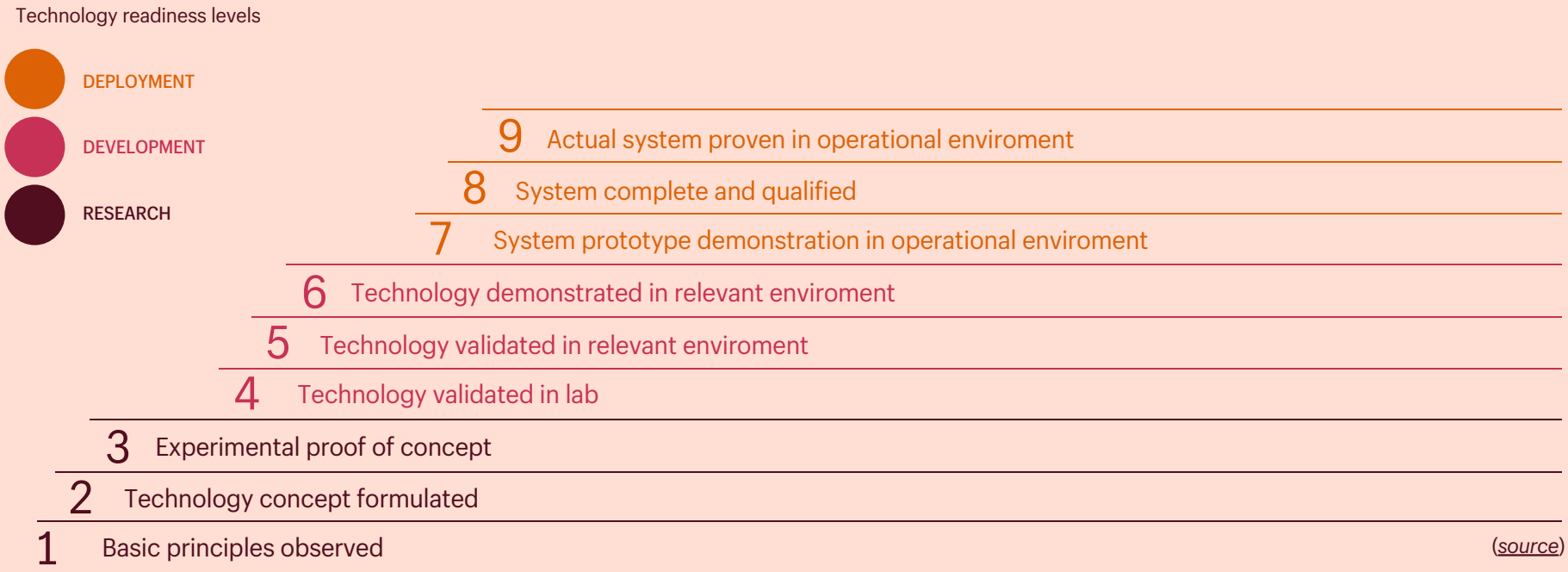
We didn't want to pick winners or put all our capital behind one solution because we need many solutions across all verticals to reverse climate change—from capturing CO_2 from waste biomass and direct air capture; to CO_2 utilization in products and mineralization; to agricultural, forest, and ocean solutions. So we explored every engineered and nature-based option in depth to identify the leading companies that are focused on scaling the most promising climate solutions.



B. Building a balanced fund

II. Technology readiness levels

We put significant funding behind companies that are commercially ready and looking to aggregate demand to secure financing for their first-generation facilities. We also pursued companies that are pre-seed and pre-series A/B funding, and still de-risking their science—because if these companies are successful, our support will accelerate their progress and encourage other investment. If their approach fails, we can cross that potential solution off our list and focus our efforts on other options. A negative outcome contributes to progress and is just as important as a positive outcome because it spurs innovation and contributes to the body of knowledge.



(*source*)

B. Building a balanced fund

III. Learning along the way

Another driving factor behind our decision to set up a balanced fund was to ensure that we could learn along the way. We didn't want to become specialists in one area, and instead were determined to observe and identify the most impactful ways to support companies in each vertical to remove barriers.

CASE STUDY ⟶ **Soil Carbon Storage**

It would be an understatement to say there are divergent opinions on the effectiveness and scalability of improved agricultural land management to increase soil carbon. Promising research suggests that regenerative practices could increase soil carbon by up to *four tonnes of CO_2 per acre* per year. Opposing research suggests this is an *overestimate*. The difficulty of accurately monitoring and verifying soil carbon at scale could mean our investments lead to no carbon stored.

It would be easy to avoid these divergent opinions altogether and focus on solutions with fewer question marks, but what if it actually works? What if developments in research, alongside new monitoring and verification protocols, allow us to accurately quantify storage capacity and develop a strategy that improves agricultural yields while pulling CO_2 out of the atmosphere and locking it away on a project-by-project basis?

To increase our knowledge on the viability of this solution, and to observe the development of monitoring and verification protocols and research science, we selected three companies innovating in this space: Grassroots Carbon, Indigo Ag, and Nori. Our purchases are helping to develop and push monitoring and verification protocols forward.

Soil sampling at a ranch using regenerative grazing practices

C. Corporate climate commitments

In September 2020, Oxford University released *The Principles for Net Zero Aligned Carbon Offsetting*. This report provides guidance and standards for using carbon removals to meet net zero targets, rather than avoided emissions offsets or offsets that provide removal with a high likelihood of reversal in the short term. They conclude that companies with net zero commitments must eventually transition all offsetting to carbon removal that permanently locks away carbon. More recently, the Science Based Targets initiative posted their *net zero guidance for public comment*. The big takeaway is that avoided emissions offsets are no longer acceptable for corporate climate commitments. Carbon removal with long-term storage is emerging as the gold standard, especially for net zero commitments.

Many companies with very large footprints *are committing* to becoming net zero and carbon negative, and when their commitment dates start getting closer, there will be an influx of buyers into the market. But what carbon removals will there be for them to buy? Higher quality and long-term carbon removal is relatively scarce and expensive right now. Without a monumental effort by companies around the world to develop and scale engineered and frontier technologies, when it comes time to honor net zero commitments companies will be forced to purchase solutions that store carbon for less time, are less additional, and are less likely to comply with emerging guidance.

Currently, there is no incentive to pay a higher price for high-quality, long-term carbon removal and fund new technologies, because it's acceptable to use lower quality solutions that are currently available. Although well intentioned, net zero commitments combined with this practice could prevent us from catalyzing the solutions we truly need to reverse climate change.

> We cannot focus only on emissions reductions and avoided emissions offsets to make good on our corporate climate commitments. We must also kick-start the carbon removal market or the solutions we need to reverse climate change will not be available to help us.

This is exactly what we are doing at Shopify: rather than being restricted by a corporate commitment that dictates the tonnage of carbon removal we must purchase (which inherently limits the average price), we have embarked on an experiment.

We plan to continue measuring Shopify's entire carbon footprint, working tirelessly to implement reductions, and continuing to invest in carbon removal at the price necessary to scale these technologies and drive down costs. This ensures we won't miss an opportunity to support a promising carbon removal solution because we can't afford the price per tonne in order to achieve a corporate climate commitment. We are removing that tradeoff because for us, it is more important to support the most promising climate solutions and to make them accessible to all than to complete an accounting exercise.

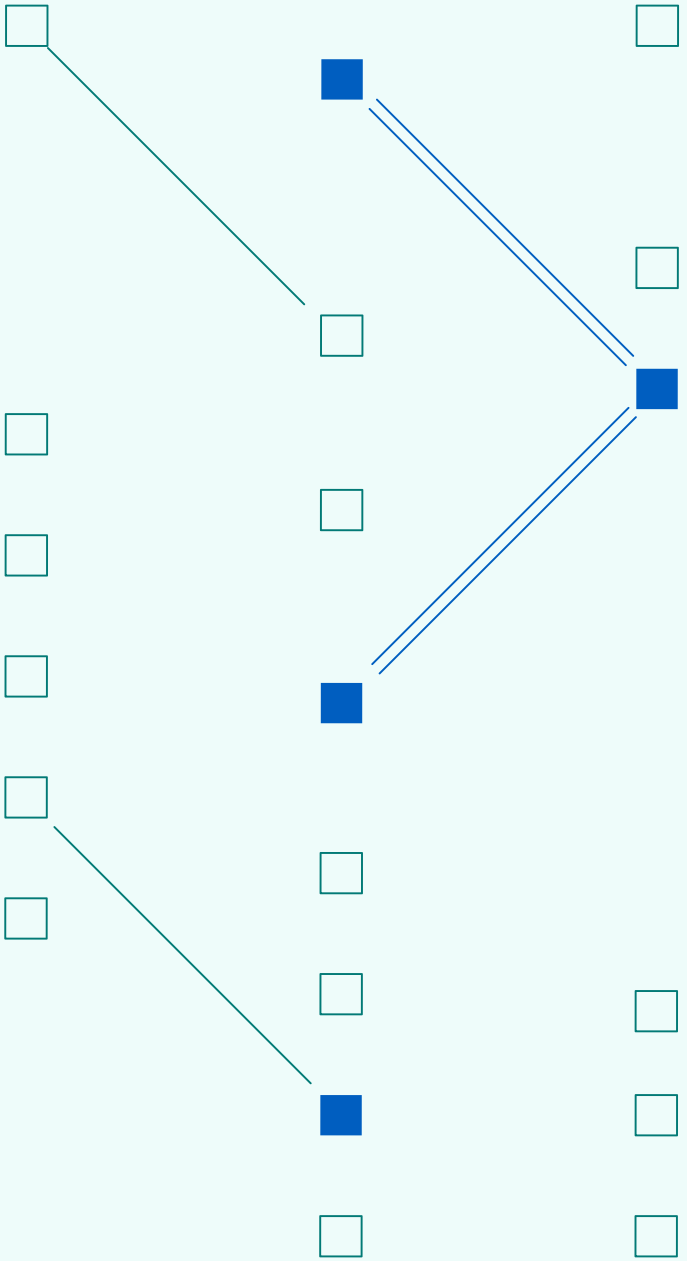
Carbon Direct published an *article* in late 2020 that clearly explains the effect that a net zero commitment can have on a company, and Shopify has decided to start at the last stage—walking the walk:

"You buckle down to the hard task of helping scale up an industry to provide negative emissions. Not all of those projects or small companies will make it, but the ones in your portfolio that do—with your help—will be real, and they'll scrub out enough carbon to cancel your residual emissions. You can reach your target of net zero and fulfill your vision, but it won't be easy. The real work has finally begun. You invest well and sidestep traps. You already envy those who will come after you once you help build the industry—but that's what it means to lead."

4. Being flexible to maximize impact

Our unconventional strategy to make our fund go further than with dollars alone.

It was critical for us to be flexible with our purchases because we wanted to support a wide range of technologies and solutions at various readiness levels. We also realized that to make our impact go beyond our $5M USD annual commitment, we needed to collaborate with companies to find ways to remove barriers, rather than pursuing simple customer relationships. We paid higher prices as an early adopter, prepaid, and entered into long-term agreements to purchase carbon removal. We wrote letters of support for grant applications, and in many cases were a company's first customer.



A. Pay a premium as an early adopter

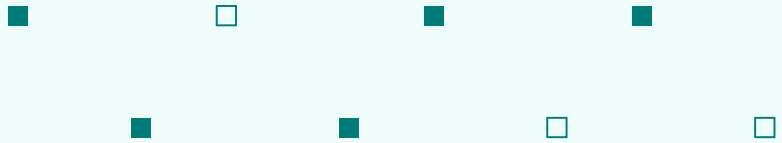
Our initial idea was to use market forces to purchase the most additional and long-term carbon removals that were already on the market regardless of price. We knew of a few promising companies like Climeworks that were seeking customers to demonstrate demand and secure financing for the construction of their next scale facility—we felt that purchasing carbon removals from companies like this was an important role that Shopify could play.

> However, as we explored the carbon removal space, built out a network, and engaged the top researchers and academics, one thing became crystal clear: it would be very hard to spend our $5M USD budget this way because there are simply not enough commercially ready solutions.

With this insight, we adjusted our approach and were willing to pay high prices as an early adopter of high-quality solutions to companies across all business stages. To each of our investments, we posed the question: "How will our funds help you reach the next stage?" Our purchases enabled companies to fund research, pilot plants, equipment purchases, and establish monitoring and verification standards.

We found a variety of companies at different stages of technology readiness, each with their own unique challenges. In terms of outstanding research, companies pursuing ocean and agricultural solutions need to prove their carbon storing capabilities. Ocean solutions also need to demonstrate their ecological safety to avoid unintended consequences now and at full scale. Completing this research is critical to unlock the potential of these verticals, so they can be accepted as viable carbon removal options.

For other technologies, foundational research is complete and the science has been de-risked—but they need support to move from the lab to proof of concept. This is why Shopify commits to purchasing any carbon that is captured and stored from a pilot plant or small-scale test.



CASE STUDY → **Planetary Hydrogen**

Planetary Hydrogen plans to revolutionize the hydrogen fuel market by replacing natural gas with the lowest cost hydrogen available, and by combining it with carbon captured from the air to create carbon-negative synthetic fuels. Their business model hinges on governments around the world enacting low-carbon fuel standards that put a price on carbon pollution from traditional fuels. Planetary Hydrogen will take a byproduct from the hydrogen production process and use it to enhance the ocean's natural ability to sequester CO_2 while simultaneously fighting ocean acidification.

Shopify is purchasing the CO_2 that will be sequestered from the product generated at their first scale pilot facility, to be brought online in 2022. As an early adopter, and Planetary Hydrogen's first customer, we are willing to pay a high price to fund research that will evaluate the ecological safety of the marine environment receiving the byproduct, and confirm the carbon storage pathway and durability in the ocean.

Mike Kelland (left) and Paige Westeinde (right) at Planetary Hydrogen's new lab in Dartmouth, Canada

B. Prepay

We prepaid for carbon removal from companies with solutions and technologies that were not yet commercially available. Companies at this stage are usually seeking seed and Series A funding.

> They are not focused on fulfilling a standard carbon removal purchase because they need to first demonstrate proof of concept, innovate and optimize their operations and equipment, and establish monitoring and verification procedures.

We could not take the standard procurement approach of paying for services or goods once they are delivered. Because Shopify's purchase is an important, and often the only, revenue stream for these companies, we pre-pay for the carbon removal and reserve a small hold-back which is released if the operation is successful. Our prepayment allows companies to run their operations and deliver the service commitments agreed to in our contracts.

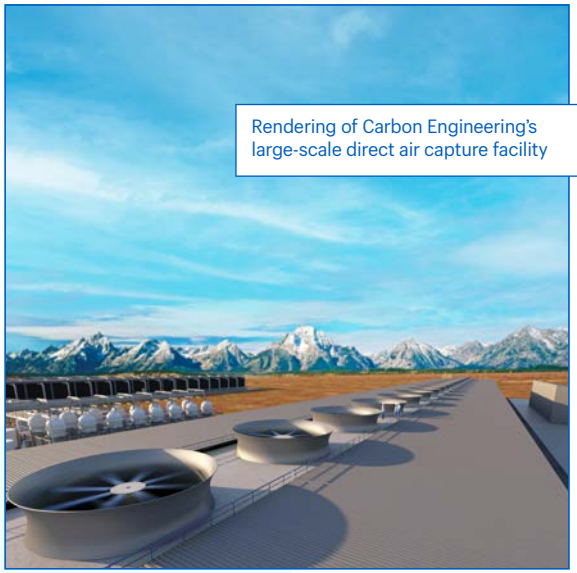
Obviously, we must de-risk this approach for ourselves as much as we can, so we have reserved hold-backs of up to 15% of the total payment amount, which will be released once the carbon removal is completed. This approach is necessary because proof of concept activities may not yield the desired results. They may fail. We recognize that the proof of concept stage can be unpredictable, and in these early-stage cases we do not require companies to refund our prepayment if the carbon removal is not successfully completed. If we did require a refund, most companies would not be interested in having a customer and carrying this liability on their books.

CASE STUDY → **Carbon Engineering**

Carbon Engineering has begun construction of their Innovation Centre in Squamish, British Columbia, Canada. They are building this facility to give their engineering team a place to optimize their technology and develop next-generation improvements to be rolled out at their commercial facilities around the world. Shopify's involvement will ensure the captured CO_2 from testing Carbon Engineering's operations gets stored. We are purchasing the CO_2 that is captured from the atmosphere at the facility and are working with Carbon Engineering to find *innovative new storage partners*.

Our combined goal is to demonstrate long-term carbon removal and support the development of a variety of storage technologies that can be paired with direct air capture. We are prepaying as construction milestones are reached and service quantity percentages are captured. This purchase agreement makes it economically feasible for Carbon Engineering to store the CO_2 and support the development of new storage solutions. By prepaying, Shopify is funding construction activities and providing an early revenue stream that supports purchases of equipment needed to compress and prepare the CO_2 to be transported offsite for long term storage.

In addition, we reserved 10,000 tonnes of carbon removal capacity from a large-scale direct air capture and geologic sequestration project that will be achieved through Carbon Engineering's development partner, 1PointFive. We have prepaid a deposit to reserve our carbon removal units and owe the remainder once the carbon removal has been achieved and independently verified. By prepaying a portion of our purchase today, we are playing a key role in helping Carbon Engineering commercialize by demonstrating market demand for their solution. This in turn helps Carbon Engineering and its plant development partners raise financing for projects and influence policy change to help develop market conditions for a global carbon removal industry.

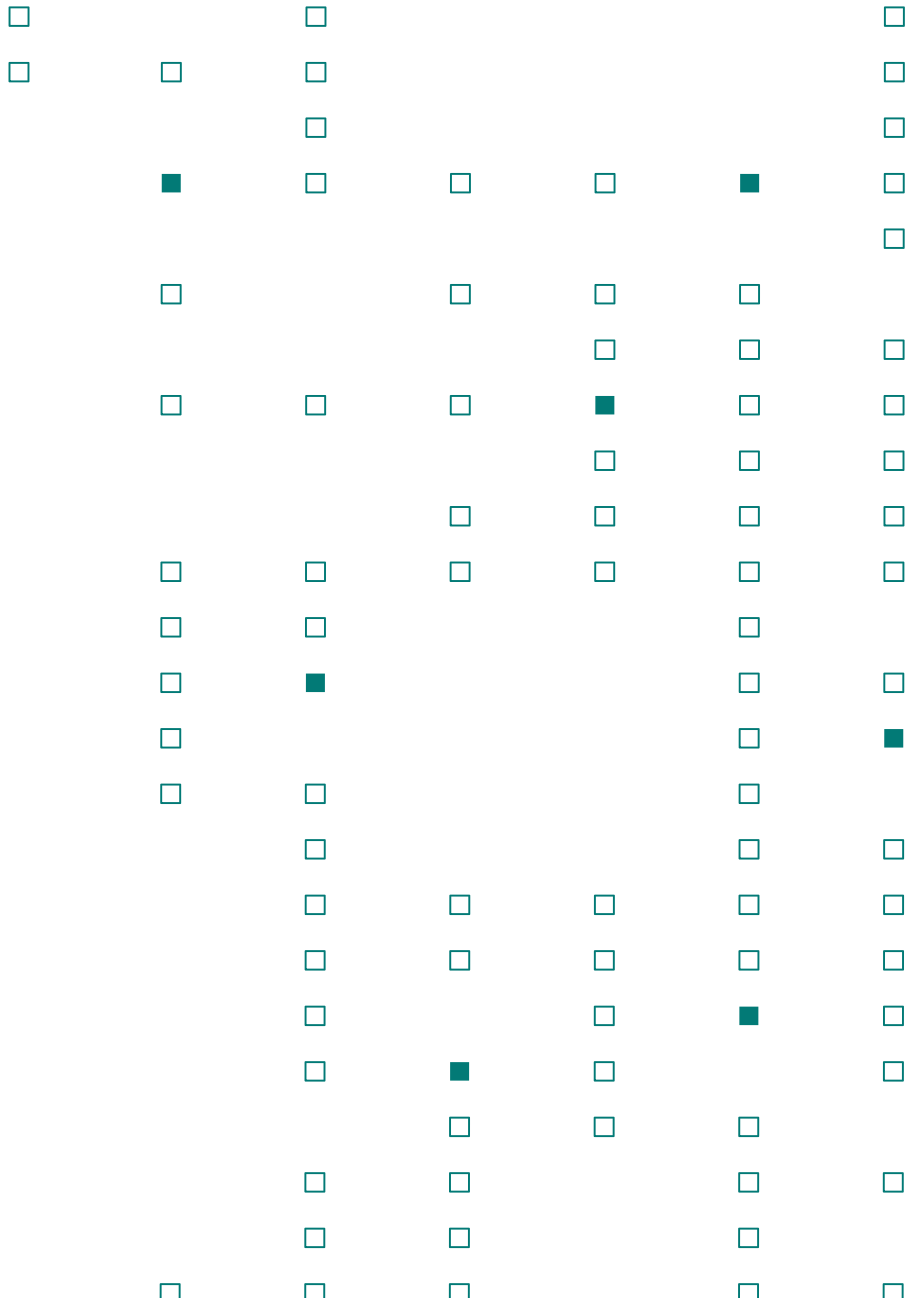


Rendering of Carbon Engineering's large-scale direct air capture facility

C. Long-term agreements

Multi-year purchase agreements provide carbon removal companies with a reliable cash flow and revenue on the books for years to come. This makes them more attractive to investors. Plus, access to additional capital can help a company scale, increase the supply of carbon removals, and move down the cost curve.

> Many of our purchase agreements have five-year terms, with options to extend for a subsequent five years, giving these companies a customer until 2030.



CASE STUDY → **Climeworks**

Climeworks has completed their proof of concept and is one of the only engineered solutions that are commercially available today. Climeworks' direct air capture technology pulls CO_2 from the atmosphere and locks it away underground. What makes Climeworks' technology unique compared to other solutions is the storage durability (the CO_2 is locked away for thousands of years) and its scalability (the modular containers can be stacked to construct machines of any size).

Construction of Climeworks' first-of-a-kind direct air capture and storage plant called Orca is well underway. Orca will be able to capture 4,000 tonnes of CO_2 per year. Currently, Climeworks is fundraising for their next plant (Mammoth), which will increase their CO_2 removal capacities by an order of magnitude.

Like many early CO_2 removal solutions, Climeworks is bringing its service to market for a relatively high price. But as more companies and individuals become customers, the scale-up of this much-needed climate technology will accelerate. This will lead to cost reductions that make CO_2 removal more accessible, which will then lead to an increase in demand and supply (the same thing that happened with the adoption of solar energy technologies).

Shopify is supporting Climeworks' scale-up and has committed to buying CO_2 removal from Climeworks for the next five years, with an option to extend for another five years. Our commitment sends a critical market signal that engineered CO_2 removal solutions are needed. Other companies and individuals can join Shopify and enter into similar purchase agreements to stack demand. This enables Climeworks to secure project financing because they have pre-sold carbon removal in advance of the construction of their next generation plants.

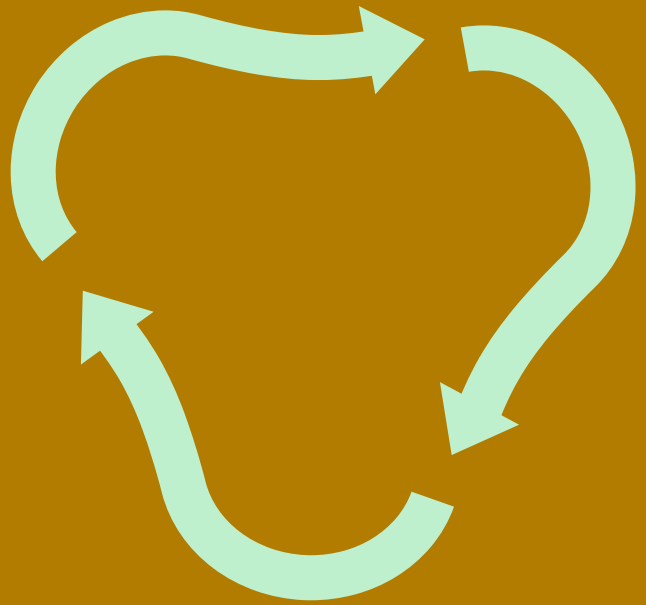
nstallation of the collector containers at Climeworks' Orca plant located in Iceland

D. What this means for businesses

Our flexible approach means we are meeting carbon removal companies where they are at. We're providing them with a lever that gets them to the next stage, moving them closer to becoming fully commercialized, scaled up, and expanding.

5. Running a strong process to identify the most promising companies

How we analyze, evaluate, and select companies developing the most promising technologies and solutions.



A. Targeted approach

During our research, we found well-recognized companies in need of capital and support to scale. We wanted to move fast, and undertook a targeted approach to seek out solutions that aligned with our mission. We built an extensive network of experts, scientists, and leaders in carbon removal. We conducted our own research and leveraged our network to complete further due diligence.

We developed relationships with potential investments and took time to understand their businesses, challenges, and product roadmaps. We often asked the questions:

- What would a purchase from Shopify do for your company?
- What barriers exist right now?
- What is your greatest uncertainty?

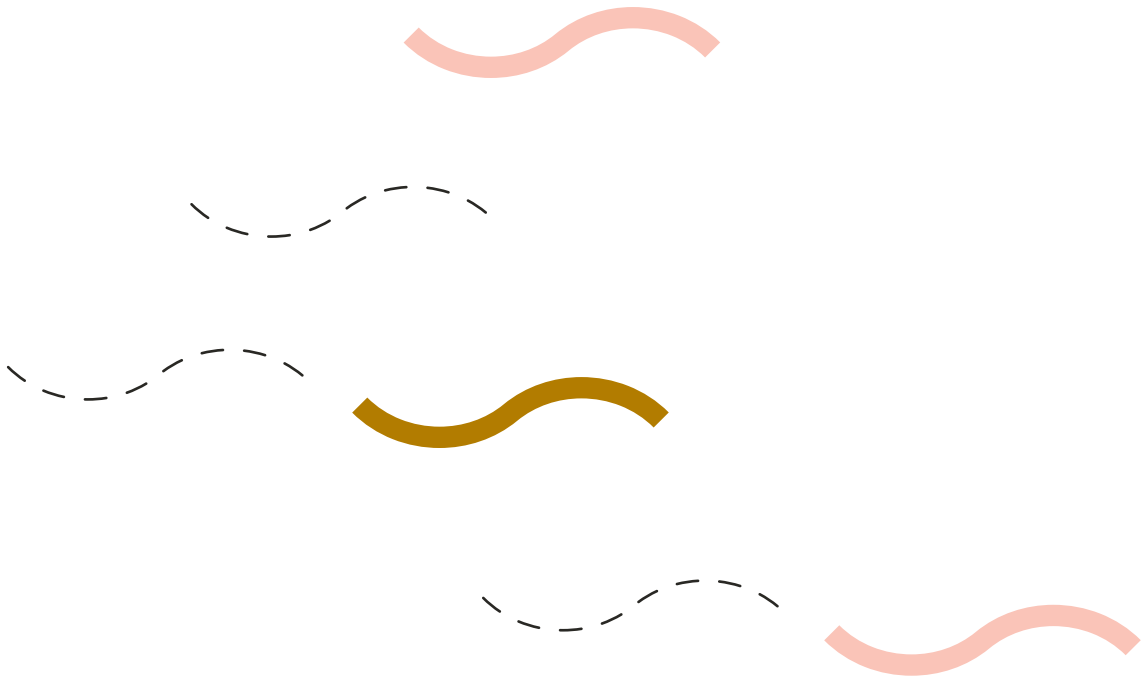
We also focused on the basics and evaluated the following:

- Life cycle analysis of the project now and at scale (more on this below)
- Potential to scale
- Target annual removal amount and cost per tonne
- Operational considerations such as potential environmental impacts and co-benefits

These questions, among others, led us to select companies with the greatest chance to reach massive scale with our support. Although we used a targeted approach, we were strict about our research and evaluation process. We developed templates and tools to guide us through each step and to arrive at a balanced decision—we'll share each of them with you below.

B. Research template

Our *research template* provides a consistent framework for investigating each potential investment. Here we document the technology/solution, company information, financial considerations, and expected market effects. This template is a living document that will evolve as we learn more about what works and what doesn't.



C. Life cycle analysis

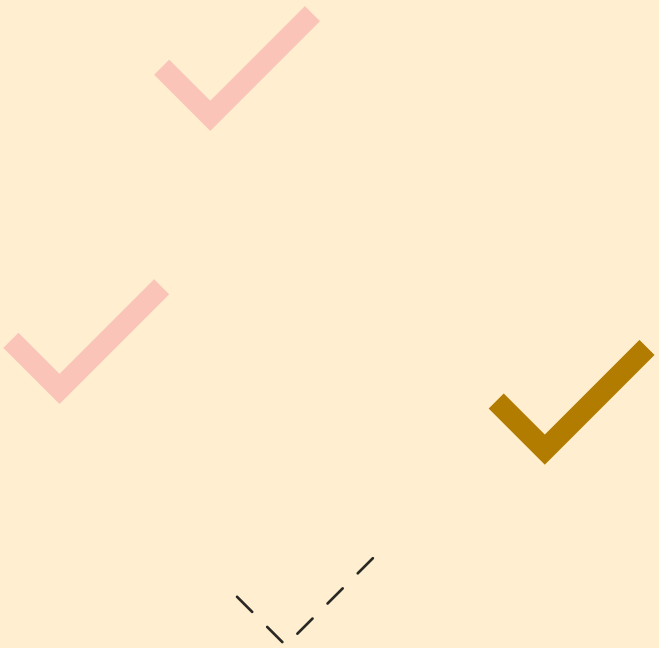
A life cycle analysis compares a project's emissions intensity to its climate benefit. This is done by documenting all the emissions that a project generates, including from manufacturing raw materials, energy usage, shipping and transportation, and weighing that against the carbon captured and locked away outside the atmosphere by the project. For a project to be viable, it must remove more carbon than it emits.

We requested that each company submit a life cycle analysis. Life cycle analyses were readily available for established companies at higher technology readiness levels, commercially available technologies, and companies supplying carbon offsets that are subject to third-party verification or standard evaluation protocols.

Many early-stage companies, however, were still working towards their first comprehensive life cycle analysis when we met. In these cases, we relied on scientific literature and advice from experts in the field to evaluate the potential removal capacity of the solution. For solutions with promise, we committed to purchase carbon removed during research projects to prove or disprove their estimated removal capacity, which enabled them to create their first life cycle analysis.

Review of this analysis is a complicated undertaking and requires a high level of subject matter expertise. Recognizing that this is a critical part of evaluating companies, we recommend using industry standard tools, and consulting widely with industry and scientific experts. We worked with Carbon Direct to ensure we understood the true carbon benefit of each company's technology or solution, now and at scale.

D. Recommendation template



Our *recommendation / decision template* is a record of the key considerations and rationale behind each investment we made. Our template includes an overview of the technology/solution, company highlights, life cycle analysis results, and the carbon storage potential at scale. The core of this analysis is a risk matrix that assesses four possible outcomes:

1. Company successfully scales and Shopify is involved *(win-win)*
2. Company successfully scales and Shopify is not involved *(win)*
3. Company fails and Shopify is involved *(sunk costs)*
4. Company fails and Shopify is not involved *(possible missed opportunity)*

This requires us to objectively look at the motivating factors and detractors of entering into a legally binding contract with a company. It standardized our process and ensured we made decisions in a pragmatic, balanced, and consistent manner, which was critical given our targeted approach.

E. Fund targets

The carbon removal landscape is constantly changing and we expect this to accelerate, so in the first year of our fund we wanted to explore all verticals to build a solid foundation of knowledge and connections, and to identify opportunities. Alongside our commitment to spend $1M USD on long-term atmospheric carbon removal, we defined an additional target of investing in every carbon removal vertical in order to have a balanced fund in terms of solution type and technology readiness level.

To monitor our progress and how the fund evolves over time, we are tracking: **Spend per vertical**

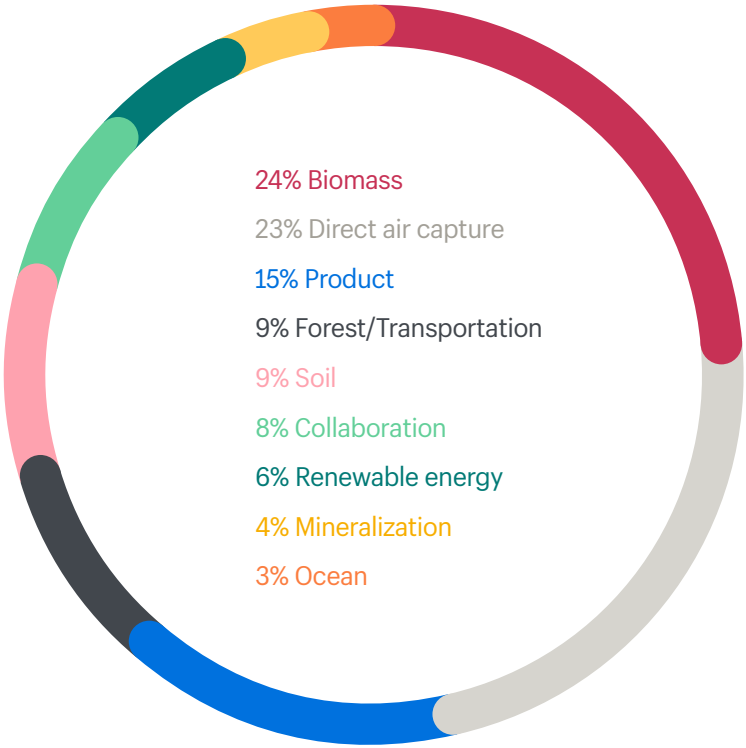
We looked at spend per vertical in three ways:

Spend on Evergreen and Frontier solutions

24% Evergreen: key solutions that temporarily remove carbon or reduce carbon emissions. We need these right now while long-term carbon removal technologies begin scaling

76% Frontier: groundbreaking technologies that remove carbon from the atmosphere and store it for the long term. Our goal is to spend most of the fund in this category each year.

Spend on an individual vertical basis



Spend on commercial and pre-commercial solutions

71% commercial
29% pre-commercial

F. Contracts

We took a customized approach to each contract because of the wide range of technologies and solutions at varying degrees of technology readiness. We developed innovative agreements that made sure our purchases were as impactful as possible. Our flexible approach came to life in our contracts, where we included prepayments and entered into multi-year agreements with options to extend.

For companies in research and pilot stages, the contracted amount of carbon to be removed is an estimate that may not be achieved. Rather than requiring companies to provide a refund, we included options to extend the delivery time period or to adjust the price per tonne upwards.

For commercially available solutions where we are not the first customer, we included stringent expectations because these companies have already de-risked their technologies which reduces uncertainty. These contracts include standard payment structures where Shopify is invoiced for services once completed, and performance requirements and penalties (such as refunds) in the event that delivery is missed.

For certain nature-based solutions that must rely on well-developed, peer-reviewed and accepted monitoring and verification protocols, we stipulated that these protocols must be in place before credit delivery and payment.

G. Monitoring, verification, and reporting

For nature-based solutions including reforestation and regenerative agriculture, we used existing monitoring and verification protocols developed by the voluntary carbon market as a starting point. These protocols contain measures to help mitigate the risk of carbon being re-released, including holding back credits in a buffer pool. This gives carbon credit purchasers assurance that the exact amount of carbon they purchased will remain stored for the expected storage term. This is critical because project-based solutions rely on land management to maintain a specific amount of carbon stored within the natural system, and this includes a series of fluxes that are subject to external factors, like floods, fires, or human error. However, these protocols are imperfect and have been subject to criticism. To better understand the risk of our nature-based solution investments, we worked with Carbon Direct to conduct deep project reviews and due diligence.

While monitoring and verification protocols for engineered solutions have not been fully developed and approved by voluntary carbon market registries, this did not dissuade us from investing in them.

We were comfortable moving ahead because storage mechanisms that rely on well-understood chemical reactions, such as the incorporation of CO_2 into concrete or reactive rock formations, pose little risk of re-release—so the monitoring requirements are more straightforward. It's also easy to verify how much carbon has been stored using simple process monitoring equipment. In cases where there is a risk of re-release, including geological storage, we expect companies to use systems to monitor the integrity of the storage system. Where available, we rely on standard protocols and reference these in our contracts. In all cases, our contracts include requirements for companies to submit monitoring and verification data and attestations that demonstrate that the carbon was stored.

H. Objectives: performance indicators

It's challenging to measure and determine if our Sustainability Fund is meeting our primary objective of kick-starting the carbon removal market because we are unable to separate out the direct effects of our purchases and communications. Instead, we observe trends and their directionality.

This is what success looks like to us:

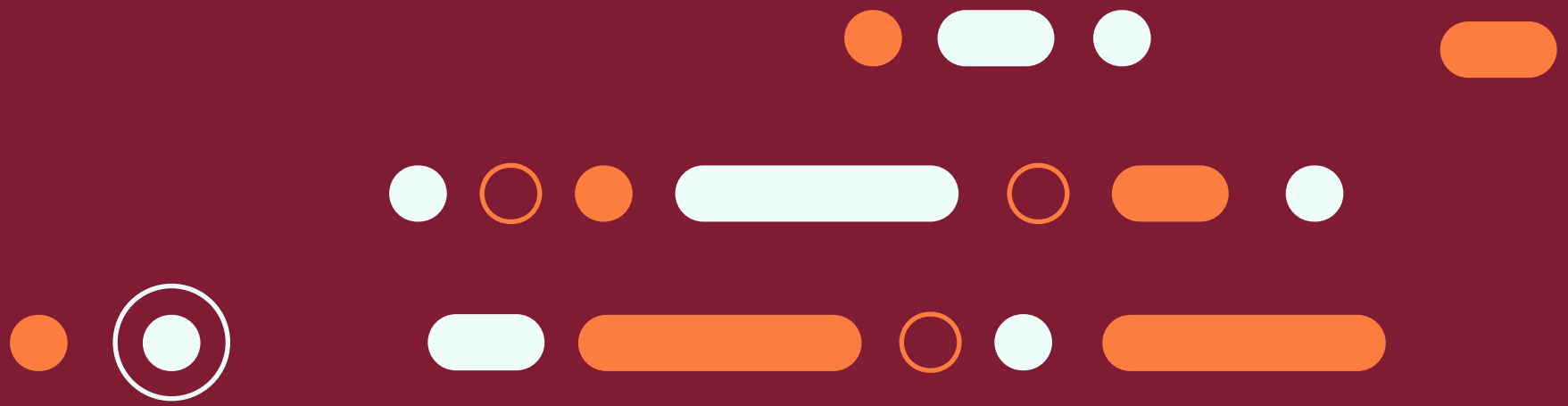
- Our fund companies see an increase in customers
- Our fund companies see increased investment and interest
- Increased capital flows to projects and companies that still need to de-risk their science
- More businesses decide to purchase carbon removal instead of avoided and reduced emissions offsets
- The supply of carbon removal available for purchase increases and the cost per tonne decreases
- The body of knowledge increases because of research we've funded that proves or disproves new methods

We have also developed performance criteria and indicators to evaluate our investments on an annual basis. Our detailed *company performance template* assesses the following factors:

- Project and research milestones are met
- Carbon quantities are achieved within contract timelines *(expected vs. delivered tonnage)*
- Monitoring and verification documentation is provided and storage term is adhered to
- Life cycle analysis performance *(comparison of expected with actual)*
- Carbon accounting, including the energy requirements and the associated energy resource mix
- Carbon return/reversal events (voluntary and involuntary)
- Open communication and information sharing on progress, obstacles, and business development
- Cost performance (reducing over time):
  - Capital expenditures per tonne
  - Operating expenses per tonne
  - Monitoring costs per tonne
  - Storage costs per tonne
- Scalability
  - Removal tonnage at scale (on track?)
  - Projected time to scale (on track?)

6. What we learned and where we are going

Some insights we've codified to help you start purchasing carbon removal.



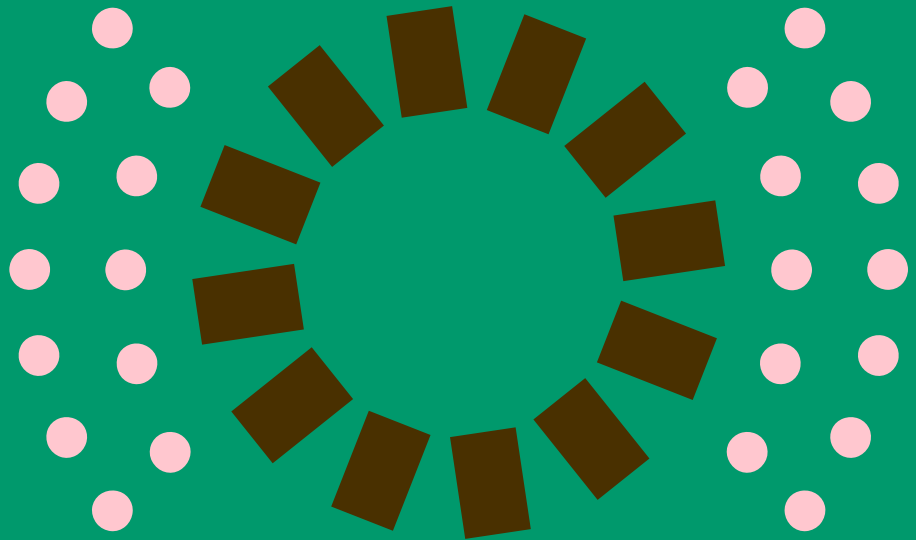
When we started connecting with companies and communicating our intent to make purchases in early 2020, we discovered there was limited carbon removal available to buy. As we have a $5M fund that renews on an annual basis, we are looking to move the money within each calendar year. We are also a capital fund and are looking to buy something rather than make donations. With few high-quality options ready for purchase in 2020, we formed the foundation of our flexible approach, to work with each company and provide exactly what they need to move their business forward.

This created a tension between needing to prepay for future carbon removal and the risk of companies being unsuccessful and folding before delivering our quantities. This makes legal and financial minds go crazy, and led us to uncouple the management of our corporate carbon neutrality commitment from our Sustainability Fund objectives. It became clear that we needed to do both: measure, reduce, and purchase offsets that we can retire against our footprint now, and also take risks to get the carbon removal market moving so that in future years the supply will increase.

With our first year of purchases behind us, the companies we are supporting have started to scale, and have increased their carbon removal quantities ready for purchase in 2021 and beyond. Now more than ever, we need other buyers to enter the market and support these companies.

7. Join us

Calling all companies—the planet needs your help.



Carbon removal will not scale with only a handful of customers. Companies in this space need more people's support to deliver atmospheric capture and long-term storage at the scale that humanity desperately needs.

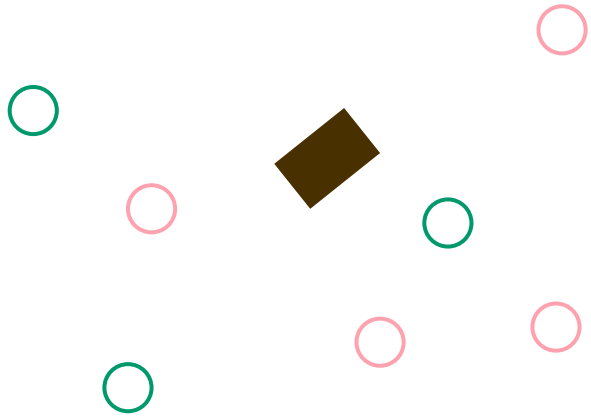
Venture capital and other funding sources are flowing into this space and now we need more customers to drive market development. Guidance and standards are quickly being developed by leaders like Oxford University and the Science Based Targets initiative. Carbon removal is becoming widely accepted as a necessary component of any corporate climate program, and this is good news: the more customers there are, the more these solutions will scale, the more the cost of carbon removal will decrease, and the more attractive carbon removal becomes to other buyers.

Some of these technologies and projects are complicated. We collaborated with the leading experts in this space to support our investment decisions. This can be intimidating and a significant time commitment for a company whose business focus is elsewhere. But many companies still want to begin purchasing carbon removal and don't know where to start.

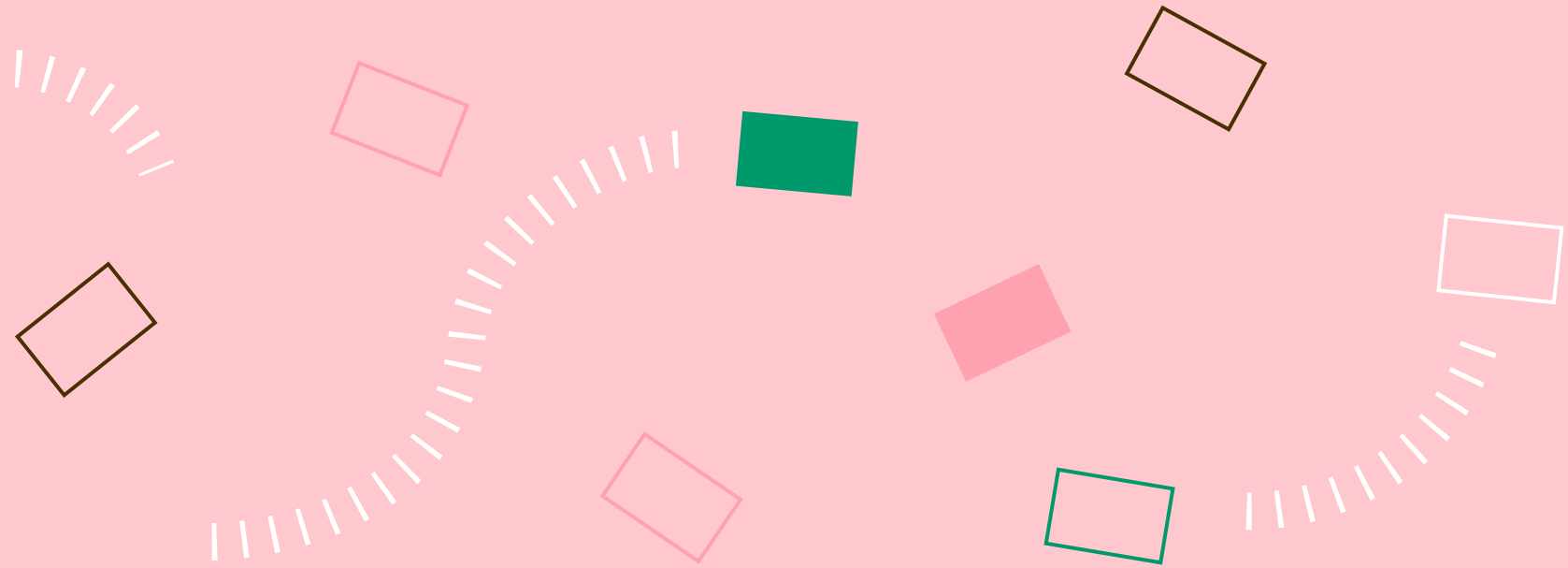
The objective of this playbook is to allow others to follow and build on what we learned. Rather than reinvent the wheel and waste time, reach out to us and we would be happy to help kick-start your carbon removal journey.

It can be difficult to stay on budget and meet corporate climate commitments while supporting carbon removal.

If purchasing only expensive carbon removal credits is a barrier for your company, we encourage you to do both: continue to execute your corporate climate plan, but also set aside some money to experiment with carbon removal. Do this with no strings attached and understand that it may not work out. Choose an amount that you are comfortable with—even $10,000 USD can get you started. This will give you the chance to get to know the market and its key players, so you can be ready when carbon removal is the only acceptable option for meeting a net-zero commitment.



We hope you embark on this experiment with us.



Templates

- Research Template
- Recommendation / Decision Template
- Company Performance Template

COMPANY NAME

Company website

Research Template

Technology

1. Describe their technology.
2. Does it capture carbon or does it rely on another source of concentrated CO_2?
3. Does it store carbon or does it rely on another process for sequestration?
4. Is carbon removal permanent? What risks exist that it is not?
5. How is carbon removal measured and verified?
6. What are the process inputs/outputs (energy, reagents, waste, etc), and at what scale relative to carbon removal (e.g kWh/tonne)?
7. How mature is the technology? Is it a novel process or an adaptation of an established process? Is there consensus or disagreement in the literature about its effectiveness?
8. What is the carbon removal potential at scale? What has to be done to reach this scale?

Company

1. Describe their business model. Are they for profit? If so, how do they intend to make a profit?
2. Who does the company compete with (if anyone)?
3. Does the company sell a product other than carbon offsets?
4. What stage are they in (concept, pilot, scale-up, commercial)? What is the timeline? Technology readiness level?
5. Do they have results yet? What are they?
6. Is the financial/decarbonization success of the company contingent on certain regulatory conditions? What are the risks here?
7. Who are they connected to? (university research groups, collaborations with large emitters, venture arms of other corporations)
8. Is there alignment in mission/values beyond decarbonization?

Financial

1. What is the estimated cost of carbon removal? Are there differences between the company's estimates and what is in literature?
2. Does the company rely on external parties to realize part or all of the carbon removal (e.g individual farmers)? How are incentives structured around this?
3. How are the costs of the process distributed? Upfront CAPEX vs OPEX? Paid by company or partners?

Market Effects

1. What does this solution displace? Are there avoided emissions elsewhere or is this replacing a carbon intensive sector/technology?
2. How many other companies are in this sector and what stage are they at? What are competing business models?
3. How long will it take for the cost curve to change? Are their efficiencies of scale or cost controlling factors such as energy costs?

Recommendation / Decision Template

Success + not involved (win)	*Success + involved (win win)*
Fail + not involved (missed opportunity?)	*Fail + involved (sunk costs)*

pre-commercial/commercialized
frontier/evergreen

COMPANY / PROJECT NAME

Investment Terms

Overview

— Vertical - biomass, direct air capture, product, forest, soil, mineralization, ocean
— Description of technology/solution
— Timeline and development stage (concept, pilot, scaling up, commercialized)
— Viability/Risks (science, regulatory, investment needs, certifications)
— Organizational capabilities (collective skills, abilities, and expertise)
— Alignment with corporate mission and values
— Who else is involved, what company are we keeping

Systems/Lifecycle Analysis

— Review of complete carbon cycle including inputs (electricity, materials, equipment, waste, water, etc)
— At scale will remove how much CO_2?

→ *Recommendation*

_____ % of spend
_____ % of tonnes CO_2

Performance Criteria and Indicators

	Objective	Example Indicators	Target	Year 1	Year 2	Year 3	Year 4	Year 5
Milestones and Execution	Contract requirements are met	Ordering, invoicing, and billing carried out in accordance with contract timelines	100%					
		Services completed and certified (if appropriate) within contract timelines	100%					
		All postponements/delays reported within contract timelines	100%					
		All reporting and documentation requirements completed	100%					
	Project and construction milestones are met	Financing secured by [date]	100%					
		All permits and approvals completed by [date]	100%					
		Construction completed and project fully commissioned by [date]	100%					
Performance	Annual service quantity is achieved	Annual total of CO_2 captured and stored	[value]					
	Life cycle analysis is conducted annually	Service quantity determined by standard methodologies, protocols, or equipment (as applicable)	yes					
		CO_2 emissions caused by delivering annual service quantity	[value]					
		Life cycle analysis provided on an annual basis	yes					
	Storage is achieved	Storage term achieved	[value]					
		Monitoring and verification systems implemented to monitor storage	yes					
		Certification protocol developed (if applicable)	yes					
	Cost reduces over time	Capital expenditures per tonne	$/tonne					
		Operating expenditures per tonne	$/tonne					
		Monitoring costs per tonne	$/tonne					
		Storage costs per tonne	$/tonne					
	Scalability is demonstrated	Tonnage captured and stored annually	[value]					
		Projected time to scale	[value]					
		Number of individual buyers	[value]					
		Number of buyers purchasing > 1,000 tonnes	[value]					
Collaboration	Open communication and information sharing	Regular updates provided on progress, obstacles, and business development	yes					
		Carbon return/reversal events (voluntary and involuntary) communicated and compensated, as appropriate	yes					


shopify