

Climeworks

January 2024

Christoph Gebald (CG): We have to remove CO₂ from the atmosphere.

We are currently the only ones offering actual carbon removal.

In 30 years down the road, this market will be as big as oil and gas is today.

Lawrence Burns (LB): What we're really doing is looking for the companies that are creating entirely new industries, and Climeworks very much fits into that category.

(CG): To our kids and grandkids, the image of an air capture plant will be as normal as today a wind farm or a solar farm is to us.

(LB): The hope is that this becomes one of humanity's big tools in its overall toolkit of how to deal with climate change.

Claire Shaw (CS): Hello, and welcome to season two of Invest in Progress, brought to you by Scottish Mortgage. I'm Claire Shaw, an investment specialist in the team. In this podcast, we take you behind the scenes to hear the conversations that take place between the Scottish Mortgage managers and the leaders of some of the world's most exceptional growth companies.

As we are a UK investment trust, we can only market Scottish Mortgage to certain audiences and in certain jurisdictions. Check out the podcast description to ensure this content is suitable for you. And, as with any investment, your capital is at risk.

Despite our best efforts, the amount of carbon dioxide in the atmosphere is still on the rise. Worse, it's accelerating. So if we're going to tackle climate change, reducing the amount of CO₂ produced is not enough. We need to reverse the damage already done.

And Climeworks is on a mission to do just that by removing carbon dioxide from the air and storing it deep underground. It's a nascent technology and the company itself is still relatively early on in its journey, but if it succeeds, its impact could be hugely meaningful from a climate perspective.

Today we welcome co-founder and CEO, Christoph Gebald, to tell us more. But first, I'm here with Scottish Mortgage manager Lawrence Burns.

Welcome, Lawrence.

(LB): Thank you for having me.

CS: So, Lawrence, this is the first company that we welcomed onto the podcast that I would say firmly sits within that environmental bucket. In the industry we see so much hype around this concept of ESG, environmental, social, and governance, but we're not an ESG fund and we definitely don't claim to be. So this is not a company we invest in to tick a box. So why do we invest in this company?

LB: Well, I think the reason is that we're looking for companies that solve big real-world problems, and Climeworks very much fits into that in terms of... We have a climate crisis. What are the different ways that we can address that? And we've already, within Scottish Mortgage, addressed it in a few different ones.

It's ironic, given the starting point there, that obviously we invest in Tesla. Their original mission was to shift us away from the hydrocarbon economy. In doing so, they've created one of the most valuable companies in the world. So the idea that you can't make money by finding environmental solutions doesn't hold in any way.

What Climeworks are trying to do is have a solution for, how do we deal with the CO₂ that's already in the atmosphere? There'll be different ways from customers, from companies, from governments, that by solving that problem they're going to be remunerated as they are today. They have some of the world's biggest customers that are paying them for that service. So what we're really doing is looking for, who are the companies that are creating entirely new industries, and Climeworks very much fits into that category.

CS: And, Lawrence, this is a private company, meaning that it's not listed on the stock market. I would say it's probably at an earlier stage than the average private company that we invest in, but it's also a relatively small holding for us. So how does a company of this size and at this stage of its journey fit into the Scottish Mortgage portfolio?

LB: So that's absolutely right, both in holding size – so we have about 0.35 per cent of the portfolio invested in Climeworks, it's at the much smaller end of everything that we do. And [also] in terms of how early this investment is and this company is, it's at the much earlier end. We don't do many of them, but we do a few.

What are the ingredients that make us want to do something like this? One is that if you're taking a very, very small holding, the opportunity set has to be really large, so that even if you're taking a small holding, it can make a big difference, potentially, for clients. Climeworks, again, is facing that huge opportunity of taking carbon out of the atmosphere, so that checks that box.

The second element is that you're wanting to be able to find something where you can learn quite a lot from them. I think as they're on that journey of creating the new industry, there's an awful lot that we can learn as an investment.

So we're very open that there's a wide range of outcomes with some of these earlier-stage investments, but we have them as very small parts of the portfolio. If they work, we'll happily devote more capital to them and grow them and own them for the next ten years.

CS: Super, thanks, Lawrence. Well, from my side, I'm looking forward to this one. I think it's a technology that people probably won't have heard of, so I think they'll learn a lot. So I'll hand over now to you and Christoph.

LB: Great.

Christoph, thank you so much for joining us on the podcast today. We really appreciate your time and are really looking forward to get to know even more about Climeworks.

CG: Thank you for the invite. It's a pleasure to be here.

LB: Great. Perhaps just starting off then, what does Climeworks do, and what problem are you trying to solve with the company?

CG: Climeworks captures carbon dioxide from the atmosphere with technology, and why we do that is climate change. In order to achieve climate targets, we have to do two things. One is reduce emissions massively and the second thing is, we have to remove CO₂ from the atmosphere. This latter piece is exactly what Climeworks is focusing on.

LB: And when did the interest in climate change begin? Tell us a little bit about your background and how you found yourself on this mission.

CG: Well, personally, I'm born 1983, so I turned 40 this year. My first exchange, or my first datapoints with climate change were in the mid-90s, so when I was in the 5th, 6th, 7th, 8th grades of high school. We were tasked to do some student work on topics that we were interested [in] and I did some investigations on energy technology, like how energy is supplied to humanity, what different forms of energy are, what the consequences are, and there was always the topic of CO₂ emissions.

So that was my very first encounter with the topic of energy, CO₂, and consequences we have to bear with it in the atmosphere and the climate system. Then it continued. Completing high school, it was clear to me I wanted to study engineering to continue that journey in energy science, energy technology, and eventually finding out the means how to counteract climate change.

LB: And what was it, think back in 2009 with your cofounder, that led you to both direct air capture but also to found Climeworks as part of that journey?

CG: The journey actually started in 2003. That's 20 years ago. Both Jan and I... We started jointly as students in mechanical engineering at the same university. That's ETH Zurich in Switzerland.

Both being born and raised in Germany and studying in Switzerland. The Swiss have a secret language, they have Swiss German and we talk High German, so we couldn't understand them, essentially. As a consequence of that, there was early days strong bonding between Jan and I, both coming from the same country, and we exchanged why we're doing that, what our mission is, and somehow it turned out both Jan and I had the same dream of one day having our own company. We high-fived on that, essentially, on the first day we met. Six years later, that was in 2009 when we graduated, we started a company right after handing in our thesis.

The years before starting in 2007, we started to scout very proactively for topics that have the potential to be commercially deployed. We came across a topic which we found super-interesting and that was direct air capture. There was an ongoing research project at the university on developing technologies to capture CO₂ from the air and we applied and, with some luck, were approved to the programme and then researched and optimised the technology that has been used. We were so fascinated by the results we had that we thought, well, there's no way but to start a company, which we then did in 2009.

LB: I think that's fascinating. It would be really helpful, I suspect, for our audience to understand a little bit about how carbon capture works, the processes and the steps within it, because I think to many people listening it would be an exciting and inspirational technology, but also one that they're not familiar with. So if you could take us through how that works, step by step, that would be really interesting.

CG: We essentially... At Climeworks we developed something like a sponge, like a solid material that has an affinity towards CO₂, a chemical affinity. So what we do is, we take air as it is, on cold days cold, on warm days warm, dry, and humid. So we take the air as it is, stream it through our system, which is filled with those filter materials that are very fluffy and porous like a sponge. The air passes through the sponge and the CO₂ selectively sticks on the surface of this material, and air without CO₂ is leaving our filter system.

Now, after a couple of hours, all sides on this filter material are filled up with CO₂ molecules. When that is the case, we stop streaming the air and we heat the system to the boiling point of water, like 100 degrees Celsius, and at this temperature the filter again releases the CO₂ molecules from its surface into the gas phase and we can suck it out of our systems as a pure gas. So we essentially

developed a device that can concentrate CO₂ from 0.04 per cent, as we have it in the atmosphere, to 100 per cent purity and can take the CO₂ that we obtain from the air for further processes.

So the big question is what to do with the CO₂, and we are using CO₂ subsequently after capturing it from the air for permanent underground storage in order to take it out of the cycle and to reduce the CO₂ content in the atmosphere, contributing to achieving climate targets.

LB: That's fascinating, so taking carbon dioxide directly out of the air and then storing it underground. Am I right in thinking it's in the form of rock, is the output of that process that you then store?

CG: There are essentially two ways you can store CO₂ in the ground. You can store it in an underground mineralisation process. This is what we're currently doing in Iceland with a company called Carbfix. So, Climeworks is concentrating the CO₂ to a pure gas, 100 per cent pure CO₂, and they're providing that to Carbfix for permanent underground storage.

What they do in Iceland is, they pump it in porous rock, it's called basalt, and the basalt in turn has a... Its surface has an affinity to bind CO₂ and turn it essentially into stone on its surface. This is one way of storing the CO₂. This is the way we're currently proceeding.

Now, there's a second way. You can also store CO₂ in underground volumes like saline aquifers or depleted oil and gas fields. This is referred to as conventional storage of CO₂, and in that case the CO₂ will not be mineralised in the ground but stay there in the form of a gas and it'll be locked away.

Now, people might wonder, well, is that safe? Yes. It's very safe to do that because those volumes have stored natural gas over millions of years and we have to go look for it and explore it, drill holes in order to get it out. So we can actually reverse what we did in the fossil industry for many decades and take the CO₂ back from the air and put it in those underground volumes to lock it away.

LB: And you have these commercial facilities that are up and running now, live in the real world, doing that. Perhaps you could talk us through the size of those facilities, the one in Iceland, for example, and why you chose that as the location?

CG: We have one facility up running in Iceland since 2021, so two years now, a facility we call Orca. How does it look like, or how can you imagine such a facility? We have eight 40-foot shipping containers as modules capturing the CO₂ from the air. Those modules we call CO₂ collectors, alluding to the modular nature of our technology.

We are stacking them on top of each other. A stack contains two of those containers. So imagine we have a U-form shape of eight 40-foot shipping

containers that are centred around a central building where we have all the computers and pumps [and] heat exchanges in order to control the plant. That's a rather small footprint for this plant. It's maybe something like 30 times 30 metres in size.

Now, as of speaking, we are currently building a 10X scale facility of that in Iceland, a facility we call Mammoth, it'll go online in 2024, which is implementing the learnings we had from the Orca facility and essentially scaling our technology to the next level. That's a scale-up pace that we're committed to, scaling on the order of 10X on a two-year horizon every two years after two years in order to get to larger quantities.

LB: 10X every two years, that's an impressive rate of change. Presumably these facilities are quite energy-consumptive, which probably links to choosing Iceland given its amount of renewables. Could you talk a bit about the energy consumption and how we should think about, for a current facility before you 10X it, what the amount of CO₂ it's able to take out of the air is?

CG: The amount of CO₂ the Orca facility is taking out of the air is a couple of thousand tons per year. Now, that might not tell you a lot, what that means. That is the unavoidable emission of roughly 10,000 electric cars, to put that somehow in context. Scaling that 10X will bring us to a facility in the range of 30,000 to 40,000 tons of CO₂ per year, which will be installed in the next year.

Now, also the big question is, how does that compare or what does that mean on our final journey – or on the journey we are on in order to achieve climate targets, which is what I alluded to in the beginning? Now, the total volumes that have to be taken out of the air with a technology like ours are estimated to be 5 to 15 billion tons by 2050. Those 5 to 15 billion tons will be split between a technology like ours but also technologies that are using other approaches that incorporate also nature-based approaches.

Now, the question is, how do we get from the platform we have built with Orca and Mammoth, a couple of thousand tons and 30,000 to 40,000 tons, to... The goal Climeworks has is a billion-ton carbon removal by 2050. The very concrete steps we're taking is, we aim at achieving multimillion-ton carbon removal by 2030.

The big news is, we just got an award notification from the US Department of Energy that we'll be seeing support in the order of \$600 million US for building yet another 10X-scaled facility in the United States in the years to come, which then will be extended to one-million-ton carbon capture capacity in the range of 2028-2029.

Now, between 2030 and 2050, so assuming you're a million-ton capture capacity in 2030, and a gigaton or a billion-ton in 2050, that's a 20-year horizon with a task

of increasing your volumes by 1,000 times. This is exactly the amount of scaling that, for example, the renewable industry like both solar and wind did between the year 2000 and 2020. In 2000 the global solar installed capacity was one gigawatt. In 2020 it was a bit more than 1,000 gigawatts with the right policy incentives, with the right supply chains, with OEMs providing the technology.

This is exactly what we are working against. We are working against to have, if you want, in the year 2030 the same platform as solar had in the year 2000, and have the right policy incentives in 2030 in place, the right supply chain in place, to scale by 1,000 times over the next 20-year timeframe. So that's the journey we are on with the platform we created with Orca and Mammoth in Iceland.

LB: That's fascinating. With those type of numbers, how do you feel and think about what you're doing and how it fits in with the other ways of addressing the climate crisis? So, whether that's carbon capture and storage at source, whether that's planting of trees, whether that's renewable energy production, how do you think of this tool fitting into that overall toolset that humanity has to deal with this crisis?

CG: Well, generally, to achieve climate targets, we have to reduce CO₂ and remove CO₂. The numbers behind that are roughly 90 per cent reduction and 10 per cent removal.

Now, on the reduction side we have all those means that you just mentioned, renewable energy like wind or solar or geothermal, instead of using fossil fuels. In case we can't avoid fossil fuels, we're using point-source carbon capture and stor[ing] the CO₂ in the ground and remov[ing] the CO₂. We have energy efficiency measures, etc. Right? This is all under the umbrella of CO₂ reduction, which is 90 per cent of the journey ahead of us.

Now, the 10 per cent part is the part we are playing in, with taking CO₂ from the atmosphere and storing it in the ground. In this domain, actually, essentially two things are existing. Take technologies like we have, to take CO₂ from the air, or take nature, which stores CO₂ in the form of biomass. The easiest thing is planting trees or reforestation projects.

Now, how is Climeworks different, or what is characterising Climeworks in this whole portfolio of climate mitigation strategies and actions? We are currently the only ones offering actual carbon removal. We are the only ones currently operating a plant that, day after day, takes CO₂ out of the air and stores it in the ground.

There are many, many, many parties that are talking about that and talking about that they will do it, but we for the moment are the only ones delivering and actually third-party-verified. So it's not us claiming that, but third parties verifying that, that we're taking CO₂ out of the air and storing it in the ground.

LB: Again, fascinating. I was also interested to pick up on your analogy with solar and other renewables in terms of where you are in that journey. I suppose with solar, for example, you've seen cost over the last decade or so probably come down about 90 per cent. If you go back further enough in time, in the 60s and the 70s, the only place where solar panels made sense was on satellites. So you've had a radical cost reduction over the years. How much does it cost today to remove carbon from the atmosphere and how do you think about that cost changing over time?

CG: At the moment, we are operating in the very high hundreds of dollars per ton of CO₂. So, think about \$800 or \$900 per ton of CO₂ taken out of the air. If you compare that, or if you hear the unit, dollars per ton of CO₂, your brain might immediately jump into offsets like carbon offsets, which... You might think about or have heard about or read about something like \$5, \$10, \$20.

You might think that's expensive, but it's not expensive if you compare it to what the alternatives are. There's a very nice study by Goldman Sachs on the cost of carbon abatement. When looking at the study, you will see that there's a good 10 to 15 billion tons of CO₂ emissions that are facing an abatement cost beyond \$800 per ton. Why so? Because there are not so many things you can do in order to abate those emissions.

So, for example, take aviation. If you travel long-haul, the likelihood that in 30 years from now, those long-haul flights will be powered by hydrocarbons, so a high energy density product like we know it today, is very high. What can you do? Either we are stopping to see each other in person and just meet via online setups or, if we think it's important for humanity that we meet in 3D – which I do believe this is the case, to make sure we live together in a fruitful manner – you need some other approaches in order to get the emissions back out of the air.

One of them is direct air capture and underground storage. The alternatives to do that would be way more expensive than the way we do it with direct air capture and underground storage. So there's not a silver bullet to approach all of the 50 billion tons that we are currently emitting and each of the solutions we discussed before has their target.

Now, the target we are having – we are always the last mile. We are addressing emissions that cannot be addressed otherwise and that are facing high cost of carbon abatement. Again, those are – the quantities are 5 to 15 billion tons, that's the estimate.

So you asked about, where will this go cost-wise? Again, currently in the high hundreds and I do expect that, in the long run, a price in the range of \$200 to \$300, or a market that is operating in the range of \$200 to \$300 for carbon removal, is a very realistic assumption.

LB: I suppose we should also mention that it's still the case that individuals can sign up as well. Anyone can sign up and pay to have carbon removed as well, which has been one of the earlier sources of revenue and commerciality for the company.

CG: Indeed, we also have possibilities for private people. Oftentimes we're approached by private people saying, hey, listen, I feel responsible. I'm wearing this backpack of CO₂. I have built a business or I have created something. I have a family. Now I'm in a position where I want to give back and actually... At the end of the day, I want to leave this planet with a net-zero or even net-negative contribution. All of those people are finding solutions with us.

We actually have close to 20,000 people right now which we are serving with carbon removal in subscription models. So they're getting carbon removal over and over. Some very renowned people are using that, like Bill Gates or the band Coldplay. If you go to a Coldplay concert, you might see a very big Climeworks banner at the end of the concert, showing that net-zero touring is enabled by a solution like ours. As you mentioned, the very early market success before actually companies acted was through people.

LB: And you mention that you are the only people doing this commercially in the real world, but it would still be interesting to talk about how you think about the competitive space in the long run. Because on the one hand, more people doing this, given, as you said, the supply constraint, probably isn't the worst thing, but how do you think about the competitive dynamics evolving over time for you?

CG: Well, again, if we take the lens of 2050 and we need to remove 5 to 15 billion tons of carbon from the air, this will be... If you multiply that with \$200 or \$300 of market price, you end up with a trillion-dollar market. Essentially, in 30 years down the road, this market will be as big as oil and gas is today. Some people allude to that as oil and gas in reverse. If you look at how the oil and gas industry is set up today, it's 10 to 20 very, very, very big companies acting in this market.

I do expect that in 2050 we'll have the same number. We'll have some 10 to 20 companies in carbon removal that are very, very big, operating on [a] global scale, having hundreds of billions of revenue, and are removing CO₂. It's impossible that a single company will be able to deal with that, so of course we are welcoming, it's good to see also others to work on that.

Actually, there are many things we have in common like, for example, policy. If not only us are advocating for a welcoming carbon removal policy but also others, this of course helps the whole industry. What's important, though, and what's our ambition is to lead the pack. We have been able to lead this industry and we're committed to continue the leadership in this domain and leadership defined by the money raised, the people employed, the agreements closed. This is where Climeworks is in the pole position.

LB: And I think when our team first started getting to know you, it was that dedication to mission that came across quite strongly. For example, the refusal to take money to build the business from fossil fuel companies, for example, was to us quite an interesting marker. It'd be interesting to understand why you took that decision early on.

CG: This is the very, very, very fundamental thought of Climeworks, that we need the energy transition to happen. We need energy reduction. With all activities we do, we want to be catalytic to this deployment. Now, I said things we're becoming less and less religious about. What you have to do is, you also have to face reality.

Now, imagine you want to build a plant capturing a million tons of CO₂ out of the air, right, as an important milestone to achieving your gigaton target in 2050, and it takes very long to develop a facility supplying the renewable energy, or you have some permitting issues. As a consequence of that, you're delaying your roadmap. On the other hand, you have the chance to use another less or non-renewable source but also sustainable source, say a fossil energy source with carbon capture to power your facility.

Is it the right thing to do or not? A challenging question. I do think if it helps you to be on track in the mid to long term, I think it's still okay to do it, but it should not be the ultimate solution of what you do. When you start to scale and you want to scale rapidly, you also have to weigh the speed of scaling into the solution. And at times you have to take compromises on a couple of the very early-day religious views you had when you set out with the firm.

But in the long run, the only thing that makes sense to me, as mentioned before, is that you're driving direct air capture with renewable sources and that both are catalytic with each other. Else we have no chance to manage the energy transition.

LB: And I completely get that it's an important part of the mission. As impressive as the technology is, and as impressive as you scaling it and bringing down the price is, you also can't give society, humanity, companies an excuse to produce more carbon dioxide. I think that's always been really clear from where you've come from. I think the final question, having really enjoyed learning and understanding more, would just be, what do you think the world looks like and can look like if Climeworks succeeds?

CG: To our kids and grandkids, I do think that the image of an air capture plant will be as normal as today a wind farm or a solar farm is to us. In 2050, it'll be completely normal to see a wind farm or a solar farm and a direct air capture facility collocated to it. We will be seeing on our end, as mentioned, a million tons in 2050, a gigaton in 2050. A plant will be the size of a million tons. So we will be building 1,000 plants until 2050. So the image of that will be a very normal one to us.

Today, if... I can't believe there was a time when people were smoking in airplanes. I think for our kids it will be the same to think about a planet where you don't see those facilities. It'll be completely normal to have that to clean the atmosphere or to have those recycling facilities. Similarly as we have water treatment facilities today or waste treatment facilities, we'll have facilities treating the atmosphere [so] that we can achieve the targets.

So that's, I hope, where everything will go to and that it's simply becoming mainstream. That's the only chance we have, is that this topic is cracking and this is why our mission is to inspire a billion people to remove CO₂ from the air. This has to become mainstream. It has to be completely normal to think about ways of removing CO₂ from the air as part of your activities, and not a specialist topic as it is today.

Today, if you ask someone on the street, hey, do you know this can be done?, 99 per cent of the people will tell you, I've not heard about that, I didn't know this works. This has to change in 2050. At the end of the day, my hope is... To end on a fun fact, my hope is, Climeworks will be a word by then. Then we know we have been successful.

LB: To Climeworks.

CG: A Climeworked future, exactly.

LB: Are you optimistic about humanity and climate change because of that power of human ingenuity and because of... Whether it's ingenuity at Climeworks and other companies on the renewable side, does that give you sufficient optimism even though there's obviously a very, very large mountain for us all to climb there?

CG: Yes, of course, [or] else I wouldn't be doing that. I've been doing that for 16 years, never bored. I have my absolute dream job and I couldn't imagine to be anywhere else. The only reason you can do that is if you believe in what you do and if you're optimistic. If I would be pessimistic, no way, you would burn out. So I'm definitely optimistic. I think us humans are mostly late to the game, but they mostly make it. So I do think that's the case also here.

LB: Yes. It's a pretty important mission and goal. So, Christoph, thank you so much for coming on and sharing what Climeworks are doing and how you're both scaling a trillion-dollar industry and helping address the climate crisis. So thank you so much for your time.

CG: Thank you, Lawrence. Thank you for the invite.

CS: That was so interesting, Lawrence, and from my side I think the biggest takeaway from that conversation was this perception that it's going to be as common to see a direct air capture facility as it is to see a wind farm or a solar farm. Just the

ambition that they have, going from where we are today where 99 per cent of people haven't heard of this technology to getting to that point, is just incredible.

But maybe, Lawrence, coming onto the investment case, we ask both you and Tom the same questions about the company at the end of the podcast. The first question that we always put to you is, well, how did you come across this company? Given what Christoph said, I'm guessing it wasn't a banner at a Coldplay concert. So how did this company come to be in the portfolio?

LB: Our Baillie Gifford colleague, Lee, was looking at carbon capture, and he was actually starting by looking at a different company, but looking at the industry as a whole, recognising that this was an industry that could be an awful lot larger over the next decade or two.

As he was researching that company in the industry, Climeworks was a name that kept coming up, and so he reached out to the company to learn about them. This was back in 2019. So that started the relationship with Climeworks and then eventually led, as me and Tom appreciated the research he was doing in the area and the insight that had built up around the broader industry, to be able to invest. We first invested in 2022.

CS: And, obviously, what's so integral to our investment process is this concept of backing founders and entrepreneurs. We've heard from Christoph today, who has just enlightened us with this industry, but in your opinion, what does Christoph bring to the table? What is it about him that gives him that special, unique edge that we're looking for?

LB: I think a really important thing is this phrase of backing missionaries, not mercenaries. Jensen Huang recently came out from NVIDIA and said that if he went back in time, he wouldn't found NVIDIA because it had been such a hard and difficult journey. So Climeworks, even if it's successful, is going to be a really difficult journey, building up and scaling that entirely new industry. It's going to be hard work.

So I think you have to have someone who is motivated by a bigger goal than just making money or even just building a business, someone that wants to change and have an impact on the world. I think with Christoph that's very much the case. This is a passion project that is driven by a desire that he believes this is something that needs to happen for humanity. I think that missionary drive is something that we see in some of the very best cases of companies that have really achieved outlier outcomes.

I think the second thing is that it's a duo. It's Christoph and it's Jan, his cofounder. They've been together for 13 years, a very strong relationship, again that long-term commitment coming through there. Christoph handles a little bit more of

the external stuff, governments, regulators, customers. Jan is more internally focused.

I think when you can identify either cofounders or a management team where there are complementary skill sets, that becomes very powerful. Because often, if you're looking for everything within a single individual or a single founder, that can be quite tricky to have. So to have a duo here, I think, is quite helpful.

CS: And, Lawrence, just pivoting slightly towards the competitive environment, I really liked Christoph's comparison to the oil and gas industry, both in terms of the size that direct air carbon capture could be, and also the makeup of it. We talked about the fact that today you have these 10 or 20 really big companies in the oil and gas space and he expects that could be a similar makeup for this industry in decades to come.

So maybe the question to you is, what do you think Climeworks has, or what is its competitive edge that would enable it to be one of those big superpowers, if you like, in this space?

LB: I think there are a number of companies in our portfolio where we see competitive dynamics that mean that this is going to be a winner-takes-all or a winner-takes-most market. I think this one's a bit different. I don't think Climeworks will be the only long-term player. I think Climeworks themselves have been open about that and in many ways they want other people to be involved in this mission.

So the analogies that he brought out are good ones in terms of the industry structure, wind turbines, oil and gas. This isn't going to be a winner-takes-all market, but Climeworks do have a really good shot at being a really material player. Why? Because they've been at this longer and in the real world before anybody else. The ability to go out and have multiple plants operating, learn from them, iterate and improve and get the data back to improve – that really is the edge, the head-start in taking that forward.

I think if there's another one, it's the fact that because you've got that head-start, you've been able to go around and build some of the investors that are going to be on that journey to support you for the long term as well, because funding here is going to be crucial. This is not a capital-light industry.

CS: Yes, and maybe just elaborating on that point, Lawrence, because we obviously have to talk about the threats and the risks in any of our investment cases, but with something like Climeworks, the challenge is almost twofold, isn't it? It's almost like the speed at which we need to find these new technologies and innovations that can help with the climate crisis and reform carbon-intensive sectors at scale. But then, as you allude to, there's also this other challenge, which

is finding patient capital and investors who can back these companies over the long term.

So how do you assess the challenges on both of those fronts there, both in the technology and in the funding side of things?

LB: Yes. So I think the real challenge is, the technology works. These are up and running in real life, in Iceland of course. The challenge is, how do you get the cost point down to a level where you're going to see real demand for the service? That's a journey that they're going to go on. It's going to be difficult. It's going to be iterative. It's one of the biggest elements of the investment case, is getting them down that cost curve over time, and making sure the cost curve doesn't become more shallow over time.

The funding, I think, is also important. The two are interrelated. The more progress and quicker you can make it on the cost curve, the easier the funding will come because you'll have stronger proof points to investors.

But I think there's a bigger one that we've come across, which is that if you look at a lot of the VC funding ecosystem, it's been built on layers and layers of success, particularly around Silicon Valley. It's been about giving people cheques to go and start the next big thing, the next big app. Those are quite iterative.

So if you think of doing a ride-hailing app, for example, you go out, you get a team, you design an app, you get a few drivers around San Francisco to show that it works, people give you more money, you scale it up to other cities, and you get a lot of proof points and incrementalism along the way that's really helpful for that journey.

Whereas, as you move into some of these more physical solutions, which I think the world increasingly needs, you need the ability to go, you know what, we need quite a lot of capital at the beginning and it's going to be some time before you get the proof points that it's working. So I think that shifts the onus even more onto people that can provide large amounts of capital and that can do so really patiently. I think the number of organisations and investors that can do that are smaller and I think Scottish Mortgage has a role in being able to do that.

CS: And, Lawrence, I think what's interesting as well is that you don't have to be a big corporation like a Microsoft or a Stripe to be involved in the Climeworks' journey. Me or you can get involved in it as well, which is really interesting.

LB: Yes. I think that gives a connection to Climeworks, to the story, to the effort. What it's allowing individuals to do is, if you go, well, I'm feeling guilty about my carbon footprint, I want to find ways to reduce it, I've just gone on a long-haul flight, how do I offset it in the best possible way and remove the impact I've just done, there is that option for individuals, and that's available on their website.

CS: Yes. Absolutely, Lawrence. Maybe just a final question for you is, how do you describe the scale of the opportunity? How excited are you about a company like Climeworks?

LB: I think it's really important to start with the caveat that it is early, but the opportunity both from an economic perspective, going back to where we started, and for a societal perspective here is very, very large. The hope is that this becomes one of humanity's big tools in its overall toolkit of how to deal with climate change.

How do we deal with the carbon that's already in the atmosphere? How do we deal with certain parts of our civilisation where abatement on its own is really hard? You can't just reduce the carbon emissions to zero, and Climeworks has a solution for that.

Christoph has run through the numbers of, could this be, as an industry, a trillion-dollar industry? When you're starting at this early stage, that means that the opportunity potentially here is enormous. So the hope is that this is a company that, if it really succeeds, could be delivering multibillion-dollar revenue streams. That becomes really very interesting.

The side point of course is, this could be a material help in dealing with the climate crisis, which affects and will affect increasingly all of us.

CS: Perfect. Well, I think that's a pretty good note to end on. Thank you very much, Lawrence, for your time today.

LB: Great. Thank you.

CS: So a massive thank you to Christoph Gebald of Climeworks and to deputy manager of Scottish Mortgage, Lawrence Burns.

To finish season two, we welcome David Jones, the CEO and founder of The Brandtech Group, a marketing technology company that helps brands make their marketing better, faster and cheaper using the latest technology.

Unlisted investments such as private companies, in which the Trust has a significant investment, can increase risk. These assets may be more difficult to sell, so changes in their prices may be greater.

You can listen to all episodes from season one and two on all major podcast platforms and you can learn more about us at **scottishmortgage.com**. You've been listening to Invest in Progress. Thank you for joining us.