DEBATE

Lucia Sinapi-Thomas, Executive Director of Capgemini Ventures

Kristinn, it looks to me as if the Carbfix solution of carbon sequestration in the soil is pretty universal and for example, you are saying that this solution can be applied to a large part of the oceans. Can it also be used as a point source solution? In my view it is eligible for both compliance and voluntary carbon markets, so a dual source of financing. What will it take to enforce wide adoption of your solution in particular?

Kristinn Ingi Lárusson, Head of Business Development and Commercialization of Carbfix

That is a very good question and I do not have a magic answer here. In regard to how we are approaching things, we are not saying the solution we are offering is a silver bullet, but as Annette mentioned, we need all the solutions. This solution can be applied on the voluntary market and also on the mandatory market. My closest examples are the European market where you have a trading scheme, ETS, where the government uses a stick on the companies, so if they do not do this they have to pay a certain tax or fine. However, in the US you are looking at the carrot where you are incentivized for doing this. It does not really matter which method is used and it will probably be a combination of both.

You mentioned before that we have had the privilege of starting this research in 2006. We incorporate the company three and a half years ago with the ambition to scale up and commercialize. We did receive a huge grant from the European Commission last year of about EUR 115 million, to build the world's largest mineral storage site in Iceland. It is a combination of subsidies or grants but at the same time, the uniqueness of the Carbfix technology is that it is already economic. If you look at the entire value chain we have two commercial operations in Iceland, and the capturing, transport and actual storage by mineralization is actually less than USD 25 per ton, which is very low. At the same time, it is a totally different approach from others, we need all the technologies of which this one and our main objective is now to scale-up globally and be available because we do not have time.

Lucia Sinapi-Thomas

We definitely do not have time and that is also a question for you, Matt. The Aircapture solution is a deep engineering solution, so it is certainly capital intensive to develop with long cycles. Is it easy to match these long cycles to the available financing on the markets and how do you see the affordability moving forward? In other words, how expensive is it for companies to remove carbon, how do you see our solution addressing this in a cost-effective way?

Matt Atwood, Founder and CEO of Aircapture

That is a great question. I think it comes down initially to the question of avoidance and permanence. One pathway is to avoid carbon emissions but that could also be counted as

taking post-combustion emissions and sequestering them. A permanent removal is fundamentally different and we are focusing on permanent removal of CO_2 from the atmosphere by capturing it and trying to do something useful with it.

When you come to the question of scale and timeframe, I think our focus is very much on our thesis, which is to solve for scale. If we take a look at the latest IPCC AR6 report and look at the required timeframes necessary to avoid two degrees of warming and consider how much capacity addition of negative carbon infrastructure technology is required to have a reasonable confidence interval of avoiding the worst existential threats of climate change, it is quite significant. We are talking about needing to scale this technology to the point where we are at about 1.5 to 1.8 gigatons of new capacity year over year by 2045. That is only to have about a 90% confidence interval of avoiding two degrees of warming. I will say here now that 1.5 degrees or around that is totally impossible. We believe strongly the global community will not achieve that goal so our focus is how we can develop at-scale technology as quickly as possible, get it to work and get on the learning curve.

We are focused on two pathways, one is direct CO_2 capture to sequestration and we are working with injection sites, such as as Carbfix is doing. We are developing projects in the US, here in the UAE and Oman where we are capturing CO_2 from the air and injecting it into the ground, but these are long-tail projects with high capital intensity and that require specialty offtake agreements for the carbon credits. The tenor of those offtake agreements has to match what it would require to finance those projects and that is a big problem. Right now in the market, especially in the VCM space, those offtakes are not necessarily bankable and we have to find a way to convert those carbon credit offtakes or bilateral agreements, into scalable project financing and to move it into project financing as quickly as possible to get on a learning curve as quickly as possible.

I think the other side of the coin where I see this technology having huge impacts is in industrial decarbonization. Corporates can choose to inset this technology within their value chain and use the carbon dioxide directly in their products or to convert into other products. In many cases, this has a larger impact than even in permanent removal and storage because the carbon intensity of the incumbent CO_2 supply is often two, three or four times the amount that is consumed.

One of the things I think is challenging is that as we move forward with the VCM and we think about how we create new standards and practices and how these enable the development of the industry. Considering the VCMI's Core Carbon Principles, these makes a lot of sense on the nature-based side. However, as we develop new engineering and hard-tech solutions and figure out how to deploy them and make them financeable, we have to be careful not to box ourselves in too much. There are major issues around the question of permanence because there are certainly examples where this technology can be used to offset existing emissions and it will have a bigger impact than taking that same molecule of CO_2 and putting it into the ground. It could have a three to one or five to one impact, but that still would not meet the permanence requirement. Then the question of additionality is very important because it should not necessarily be the case that the project economics require a carbon market offtake in order to finance this infrastructure. There are two critical items of concern here, one is that it makes the projects much harder to finance and less bankable, and two, it slows the scale of adoption, which I think is the most critical part of getting the costs down, particularly as it relates to CDR technologies. Wright's Law says that with every doubling of capacity typically brings a 15% to 20% reduction in costs. You could pick a random number right now in terms of how much it might cost to pull CO_2 out of the air, call it USD 600 or USD 500 a ton, but you could say that after about 60 plants you could be well down the cost curve to under USD 100 a ton, which we think is well within target of the technology we are developing. The question

becomes how you deploy that technology as rapidly as possible, get on the cost curve, but do it in a way that is financeable and bankable so that we can get to scale quickly.

Lucia Sinapi-Thomas

Corporate adoption for their own industrial usage, and we see that both these solutions could be dual-track, for reduction, avoidance and removal, is a way to channel more funding which is essential to accelerate the width and pace of adoption.

We have a couple of minutes for questions.

Friedbert Pflüger, Director of the European Cluster for Climate, Energy and Resource Security (EUCERS) at the university of Bonn, Founding Partner of Strategic Minds Company GmbH

I just want to say that this was a fascinating debate and I learned a lot. I have a question for Maryam. We have the COP ahead and surely these topics are important enough to be at the top of the agenda? Yesterday, we heard Mr. Fabius talking all the time about renewables, which of course, we all know is very important but the potential of getting CO_2 out of the atmosphere or storing it under the ground is so tremendous that perhaps we should put more emphasis on CCS and carbon capture and use in the COP process and that would be fantastic if your country could pave the way for that.

Maryam Al Mansoori, General Manager of Rebound

Thank you so much. From what I am aware within the COP28 team, I do not know that carbon is a very prominent topic and I think it will be a major focus of the conversations. Also, given the business space I am in, I am aware that a lot of carbon capture technologies with trades of carbon credits and exchanges are going to be coming soon. I commend the COP28 team ahead of time but I am sure that we will all be happy and satisfied with the results when it is over in Dubai, so inshallah, more positive news soon.

Friedbert Pflüger

Matt made a suggestion about financing start-ups in the direct air capture field, for instance. Is that not also something you should engage with? We heard Mrs. Al Mheiri saying yesterday that you want to emphasize financing tools and I think Matt's idea is wonderful and it would be tremendous success if it was on the COP agenda.

Yann Coatanlem, CEO of DataCore Innovations LLC, President of Club Praxis

Those solutions are all very exciting, the question is how you scale them and what percentage of the overall problem you could each solve in your different areas.

Kristinn Ingi Lárusson

I can start. From the point of view of Carbfix, we are project and operating two projects in Iceland with a third about to start next year. The issue for the technology is that we are replicating exactly how we are doing things so it is a question of injection wells and finding the right subsurface and geology. The cost benefit is already there, it is now about policy and regulations in each country and state, which are different. I mentioned before that I cannot emphasize enough that we not have time, so coming here and educating people on the possibilities is very important but policy is the biggest obstacle.

Matt Atwood

I would second that notion but really add that project financing is really at the core of the scalability issue. It provides two functions, first is the project development itself, so figuring out how we can make these projects bankable and scalable independent of the costs of the removal, as the product at this time is on the critical path. As we scale the technology, even in the earliest stages and highest cost as risk of the technology, we are still able to beat the incumbent gas or industrial fuel companies on price parity by pulling CO_2 out of the air and making the exact same product, and that is without counting carbon credits and things like that. If we can start banking these projects and scaling it, that will then enable us to start scaling the manufacturability of the facilities and getting manufacturing up is what we are focusing on right now. Our vision is that these machines should be built like cars are built today and it is about how we get from here to there. You asked a question about what size of problem it could solve. If we made enough direct air capture machines that are roughly equivalent to the total number of automobiles manufactured per year today, that would solve 100% of the problem. Of course, direct air capture is not going to be 100% of the problem and there is a question of the solution, energy costs, capital costs, etc. However, if we look at it as an infrastructural investment, we have to keep in mind that these negative carbon technologies are additive over the lifetime of the project. It is very different from renewable where you build a wind or solar plant and it does not produce carbon, while these assets are removing carbon dioxide every year over their 20 or 30-year lifetime. I think we have to take a different approach and different policy approach to thinking about how we can backstop this financing, provide technology performance guarantees and creditworthy offtake agreements that are bankable.

Randy Kotty, Head of the regional economic service for Provence-Alpes-Côte d'Azur

I am going to advertise for my country because we are investing a lot in carbon capture, so reach out if you want to invest in France. Kristinn, you mentioned USD 25 per ton and Matt you mentioned something like USD 500 or USD 600, can you give us a ballpark figure for where the industry is right now in terms of cost per ton captured? How far down the line can we go on the cost optimization that you mentioned?

Kristinn Ingi Lárusson

We support one another so Matt is starting by catching and I am taking it and getting rid of it and we do this jointly. We have published a paper on this so there are no secrets there and of course, transparency is very important there. We do have proprietary technology to capture using water scrubbers and that cost is approximately USD 20 per ton but that is using a type taken directly from geothermal steam. We transport it and then inject it into the ground, so the rest of the cost is less than USD 5 but this is a scenario in Iceland. We are working on a large project called the Coda Terminal where 3 million tons will be mineralized every year, transported from mainland Europe to Iceland in liquid form. The cost there will probably be around a minimum of EUR 25 per ton, which is just for the storage part, but this is the first of a kind, so by scaling up and having it closer to the source, the cost will be lower, just as it is in Iceland.

Matt Atwood

The costs associated with direct air capture and where we can get to, we are well on the target of getting below USD 100 a ton of CO_2 captured from the air. Pulling CO_2 out of the air is not useful, the CO_2 has to be a liquid, a high-grade liquid, or a supercritical fluid, so we have to integrate systems to get the CO_2 to a saleable form or an injectable form. That requires putting more systems together, and that requires additional energy and capital costs. When you breakdown the overall costs of atmospheric CO_2 removal via direct air capture, today there are some companies that have published results of where they are at and the typical

range is USD 600 to USD 800 per ton. However, this cost is heavily dependent on the cost of energy, so as we scale-up manufacturing and cost down the technology, we see no way where the capital cost contribution of the technology over a 10 or 20-year amortized project lifecycle cannot be in the USD 20 to USD 40 per ton range. Then, if you take the energy cost associated with moving 3 000 tons of air for every 1 ton of CO_2 that could be captured, and the energy costs of converting into a saleable product, we can estimate that is about 1 000 KWH per ton of CO_2. At USD 0.10 per kilowatt-hour, that is USD 100. We are well within the range even with retail price power to be in the USD 100 per ton range over time, but that assumes that we take good progression along the learning curve and then the question is how we iterate on that as rapidly as possible. I see no technological reason why we cannot achieve USD 100 per ton direct air capture within the next five or 10 years.

Lucia Sinapi-Thomas

We will take that as a promise. I think with this we will close the panel. We thank you for your attention and I thank all the panelists, and thank you, Sam, for rising early London time to be with us in video.