

## Linde | Goldman Sachs Carbonomics – Fireside Chat

November 16, 2021

Bob Koort:

Hello. Hello, everybody. This is Bob Koort, head of the equity research effort on the chemical space here in north America. Welcome everyone from around the world. For our next session, we're super excited to have Sanjiv Lamba, who is the COO of Linde PLC and also the CEO elect. Let's get right into it. Sanjiv, thanks so much for joining us. I wanted to start out-

Sanjiv Lamba:

Glad to be here, Bob.

Bob Koort:

Those who aren't maybe as familiar with the Linde story, you guys are the largest industrial gas company in the world. Can you just give us a little background on the company, overall? And then, maybe segue into your involvement into the clean hydrogen space?

Sanjiv Lamba:

Absolutely, Bob. Let me just describe Linde for you. I think you did a bit of that already. We are the largest gases and engineering company with the best global footprint. That kind of positions us well in terms of this whole new trend around clean energy that we are seeing, Bob. I think this is where I'm going to focus my attention in describing Linde a little bit more, because it'll help both get a little bit of perspective on what we bring to the table, but also describe where we stand today as well.

What do we bring to the table? As far as clean energy is concerned and clean hydrogen in particular? Linde has a full suite of technologies, Bob, that span the entire value chain of clean hydrogen. Starting from production whether it's gray, blue or green to storage and distribution. Again, Linde was the first company to put a cavern in for high purity hydrogen underground storage, but also numerous tanks across the world. A very highly integrated pipeline infrastructure in many parts of the world that sets us up for distribution efficiencies, if you will. Some of the leading technologies around movement of hydrogen, whether it's in liquid form in tankers or high pressure tube trailers as well, right to the point of consumption where we provide, I have to say, with some pride, the best hydrogen refueling stations anywhere in the world. We have 200 of these currently operating all across the world. That's a technology piece that we bring.

In addition to that, we've been in this business for more than five decades, Bob. A lot of people who talk about hydrogen today and they get excited about it. I'm happy for them. But the reality is they've never seen a hydrogen molecule. Of course, it is colorless and difficult to see, but people bounce around lots of colors, you've got gray, blue, green, brown, yellow, turquoise as well and so on and so forth. But of course, it is a colorless molecule that requires some care and handling, in storage, in purity and from a safety point of view as well. That five decades of experience gives us the insight we need to be able to move that forward.

And finally, the thing that I think is very important is where are we today? We have a hydrogen business today, more than \$2 billion. We expect to see that, I'm going to say quadruple, over the next 10 to 15 years. We have a very strong aspiration to move in that direction and we've seen great

momentum building up in the broader macro level, which is providing the energy that is needed for that momentum to kind of move in that direction.

But again, as a business, that's got five decades of experience and extensive technologies, we also have a highly established asset base that currently is available to help move this growth forward. And that asset base, as I said earlier on, includes storage, tanks, includes tankers on the road, includes tube trailers on the road, includes the pipeline grid. All of these assets are agnostic to color. It doesn't matter whether it's gray, blue, green, or any of the other colors I mentioned earlier on. These assets will move any of that product and make sure it gets a point of production to the point of use in the most efficient manner. That's kind of in a nutshell how I'd see us positioned as far as the clean hydrogen space is concerned, Bob.

Bob Koort:

Sanjiv, there seems to be some debate about the path forward in hydrogen blue, green, gray, et cetera. Can you talk about what Linde sees as far as the clean hydrogen markets evolution? What are the key triggers you need to see for this opportunity to really materialize for the company?

Sanjiv Lamba:

Yeah. Great question, Bob. This is our view, both at Linde and my personal view as well, which is that we have unrealistic expectations in terms of how this space is going to develop. And while we have the best green technology in terms of our JV with ITM, for electrolyzers, we also recognize that there is a technology roadmap to getting to a point where you could have green at scale. I'll give you some data in a minute just to kind of illustrate that point.

But let me just go back and talk about blue, because I feel with a great deal of conviction that the most... If you think about blue, any country that today has natural gas resources has the option to look at, indeed, I'd say, must look at blue as the interim solution until we get to a point where you've got green at scale. Blue provides a significant and a very effective bridge to getting to that ultimate, ultra low carbon intensity hydrogen that you need. We can call that green or any other color. In my mind, blue technologies to do blue are available today, they're available from Linde. We provide that whole technology package and solution. They're available in terms of the ability to work with partners in our case, to get sequestration and storage done and to be able to provide blue hydrogen, essentially tomorrow, if that is what was needed.

Now, a number of projects we're working on indicate exactly that, so we know that there is broad recognition in markets, such as the US, Canada, Australia and growing recognition in the middle east, that here is a very viable cost effective ability to take hydrogen and provide blue hydrogen. And in some cases, blue ammonia, as a carrier for moving, moving the blue energy around the world.

Now, I see the transition to green. I see that scale up happening towards the backend of this decade. I firmly believe that green technology will evolve. I say this with some conviction, because I know that we are working on a technology roadmap that's going to get us there. You are talking about substantial shifts over here. Examples in this would be significant cost down on the capex you're talking between 60% to 70%. We are working with ITM on a technology roadmap to make that happen. You're talking about scale up.

Today, the biggest PEM module or stack is two megawatts, from Graham, who's also joining this session. Two megawatts, that's the largest. People are talking about setting up gigawatts of hydrogen capacity. There's a gap between the reality of where we are today and the aspiration that we have. The technology roadmap that we have is helping us move that forward to ensuring that we have stacks and modules, which move from two megawatts to five megawatts, to 10 and 20 megawatts, because at that

point, 100 megawatt plan, which are still small by comparison, will only need five modules. And obviously, all of that helps bring that footprint and the efficiency of the electrolyzer capacity and make it effective in this transition. Of course, we've got to work beyond that as well, if we are going to get to that gigawatt stage, but really, the backend of this decade is where I see that scale up gathering momentum. Hopefully, that kind of gives you a sense of how we see this moving forward.

Bob Koort:

And so, just to add on that, Sanjiv, is the need for blue to create the infrastructure, the demand environment, so that you can get to the green in the future and also bring that cost curve down, so it can be cost effective, is that sort of the big picture?

Sanjiv Lamba:

In my mind, that is true. But I have to say, Bob, the smartest countries I would say are not worrying about blue and gray at this point in time. They're looking at building the infrastructure, utilizing the available hydrogen, which is a better substitute to any other alternative, even if it's great, and building the infrastructure, creating the ecosystem necessary to move forward. South Korea for us is a great example of this. We're seeing China and others also move in that direction. Create the infrastructure, leverage what's available, whether it's gray or blue, and then build out to ensure that that transition, ultimately the green or ultra low carbon intensity hydrogen as I like to call it will ultimately happen. I think that's absolutely the right strategy to follow.

Bob Koort:

Can you give us a flavor of your own project pipeline? What's in the plan? Have you announced scale? And obviously, you talked about some of these PEM farms becoming incredibly large versus today. What does that sort of ramp look like in your own project backlog?

Sanjiv Lamba:

Bob, that's a great question. I've talked in the investor calls at a somewhat superficial level about the project pipeline and what we are seeing. We're seeing anywhere between 250 to 260, 270 projects at any point in time. We did our recent Linde Hydrogen Council meeting and I think we had about 257 odd projects in that pipeline. We are seeing weighted probability, weighted CapEx. I keep making this point of about \$4 billion. I make the point that to get \$4 billion you need a pipeline that's a multiple of that. The number of projects and the size of projects that we are looking at is actually incredibly large to get us to that \$4 billion. That \$4 billion is what I think will likely be seen in decisions we'll be making over the next two to three years. Again, that, that kind of gives you a sense of both magnitude scale and the number of projects we talked about.

Let me try and describe these projects in a little more detail today. Let's start over with blue. We're seeing blue projects, as I said earlier on, in the US, in Canada, in Netherlands, Australia, in these areas where clearly they have a natural gas advantage. We are seeing the players over there work closely with us to try and understand how carbon capture and sequestration happens. And as we think about these projects, Bob, and I want to kind of bring on this concept of the triangle. I kind of draw it on the whiteboard and explain this to my team. But I think of these projects having a triangle, right? Three points, you need a company that has the ability to provide the technology solution for it. In this case, this is us. Leveraging our own zero emissions or aggregating other people's zero emissions and providing a carbon capture solution as a first step.

In the triangle, on the other side, I see a partner with us who provides a storage and sequestration capabilities and expertise. We recognize it's not the area that we participate in from a point of capability, so we want to bring a partner in who can actually compliment us on that to create the capture and sequestration model. We've got those two elements sorted out. But there's a third very important element. It's on the top as you can see off my triangle. And that element is an offtaker. For me, for a project to be meaningful and for us to invest time, energy to develop it, we need to have an offtaker in the mix. Either as part of the developer structure itself or as an offtaker arms length, but that is super critical for those projects to happen.

And again, I'm pleased to tell you that a large number of the projects that I talked about, of the 257 projects, there are a number of projects where we have this triangle playing out as we speak. We are developing projects and the US gulf coast is one great example where that is progressing or in Canada or Netherlands, real projects that are moving forward with all of these elements coming together. That's not-

Bob Koort:

Sanjiv, could you maybe talk about- Oh, sorry.

Sanjiv Lamba:

I was going to talk about green [crosstalk], Bob. Unless- Okay. Let me just talk through the green, please. We are seeing an equal number of green projects. By the way, when I look at my portfolio of the larger projects I'm dealing with, there is about a 50-50 split at the moment between blue and green. And because of the technology advantage we have working with ITM, we firmly believe that green and the technology roadmap will get us to a point where it continues to be very interesting.

Now, for green, what we need is, as you know, reliable, renewable energy, right? I mean, the key elements of a successful green hydrogen project really is linked to reliable, renewable energy, solar, wind, et cetera. Obviously, the areas where we are looking at these projects tend to be a little bit different. We are kind of looking at Germany... I'll talk about Germany specifically, because I think it's about linking to other countries which have that wind power. The UK, again, a lot of wind power. Oman in the middle east, Emirates in the middle east. India, China, Australia, I spanned the wall. That's kind of where I'm seeing... I'm seeing it in Chile, in Latin America. That's where we are seeing the green project's development happen at the moment.

The two types of green projects that we're working on. One, where they're meeting a local requirement. These are the smaller end of the projects, if you will. They tend to have a local... And they tend to be smaller in size and scale as you'd expect. They have a local demand that's been pursued. Then we have a number of projects which are the larger green projects. The one in Oman as an example is a good example of that. We are working together. I think that there is an existing ammonia plant. We are kind of feeding into that with green hydrogen inputs to make sure that there is availability of green ammonia for an export market in that instance. We believe that ammonia is a great carrier.

In many cases, as an energy source, ammonia is a very efficient and energy source as well. Until such time we have large scale liquid hydrogen movement across the world, ammonia is a good carrier as an interim. And of course, where it's consumed directly as an energy, in Japan, as you know for energy production. I think that that is a good market that has a dynamic that makes sense from an energy balance point of view as well. Again, that's kind of the scale of green projects that we are currently working on.

Bob Koort:

Can you talk a little bit about whether gaseous or liquid hydrogen makes the most sense? How you see the development path for each? And maybe similarly, do you expect ammonia as a long term solution here, green ammonia or do you think that is a transition period towards more of a hydrogen network?

Sanjiv Lamba:

Okay. Both great questions. I think that the liquid to gas question has come... I've heard it a few times now. Maybe I take a step back and talk about liquid gas a little bit first and then kind of get into the dynamics of it. As far as mobility is concerned, just to make sure that everyone's on the same page, all mobility today, all vehicles today use Gaseous hydrogen only, right? Even where we set up liquid refueling centers, in the end, what we actually fill in the tank of the car or the bus, or the truck is still, gas.

There is development ongoing. We are participating in that development, which is looking at moving that to liquid. And obviously, it comes with some complexity, as you can expect. If there is liquid, clearly, there will be some boil off or venting that happens because of the ambient temperature being different to the extremely cryogenic liquid hydrogen that we would be storing in that. It's about managing that safely is where the challenge lies. You don't want to have a hydrogen truck standing out in a garage, which has got a vent line and hydrogen coming off that. From a safety point of view, you don't have exposure to potential flammable sources, which would then result in consequences you don't want. There's a lot of development around that. It's a tricky topic. And I think we are kind of looking at technology around that is really about pressurizing liquid to get there.

Why is that the holy grail? I'll just kind of spend a couple of minutes on that, because again, people get excited about this, and I think it's important to just describe it. The holy grail for liquid hydrogen is if you can have liquid hydrogen fill times of 15 minutes, let's say, you can put in 70 to 80 kilograms of liquid hydrogen into a class 8, 40-ton truck and give it a thousand kilometer range and not compromise on the payload. At the end of the day, the beauty of hydrogen is that it works really well for heavy goods, vehicles, buses, ferries as we've been developing in Scandinavia, trains, et cetera. There is a trade off between payload and how you get enough hydrogen onboard to make sure that you've got enough range. Today, hydrogen trucks are about 300 kilometers, 350 kilometers. Clearly, the range needs to move beyond that. And to get to that 1,000, is where liquid comes into place. That's kind of where all the exciting development is happening. We are kind of deeply engaged in that and it's an exciting opportunity, I think, for that technology to move forward.

The other piece around liquid is the economics of liquid. Liquid does cost more by the way. There isn't cost added to getting from gaseous form to liquefaction of hydrogen. It costs more, but it gives you benefits economically. Why? A, because you could transport liquid over long distances economically, to try and do the same with two trailers, is what we call them, for moving hydrogen in gaseous form at high pressure. You need a one to five ratio. For one tanker of liquid, which I can carry, let's say between four and a half to five tons in that tanker, I need about... This is the latest technology of two trailers, I need about five of them. If I go back to the previous technology, I need 10 of them. The economics of just moving product... You can think of compressed natural gas versus LNG is a good analogy over here. The economics are moving that product are just so much better and you have so much more control over managing that supply chain.

The other piece, of course, is that the footprint of a liquid installation is much smaller. And so, if I'm in a congested area in South Korea, as an example, in Incheon or outside Seoul, these are congested areas, highly dense, you want to have the smallest footprint possible. There is no land is spare, so you want to make sure that it is a safe installation and the smallest footprint available. As we are building in South Korea, the country's first kind of infrastructure around liquid hydrogen, we have had to contend

with a lot of this as we've gone into our planning stage on this. And now, the execution is kind of going well, because we've taken these decisions, keeping liquid in mind. In that sense, the economics of liquid actually play out quite well. I see that development moving forward. I see short distances you could do with gas, longer distances and larger payloads, liquid will be the obvious option in due course.

Bob Koort:

Sanjiv, earlier, you mentioned your triangle, which includes, partnering where others have competencies or where you can leverage the integration. Can you talk a little bit about your key partnerships and what areas they're helping you with?

Sanjiv Lamba:

Absolutely. Well, before I do that, I'll quickly address your point on ammonia, because I know I kind of skipped over that in my previous response. Just briefly, I think ammonia, as an energy source and in some cases as a direct feed stock for producing power, with Japan is doing a lot of work around at the moment, it is a good product that's going to have a long term future. It also provides a great, as you suggested, a transitional or an interim carrier for clean energy across the world, because it has the ability to move. In due course, will liquid hydrogen overtake that? My view is once we see development in that space, large scale, that possibility does exist. And I think that's where the carrier versus hydrogen will actually play out longer term.

Bob Koort:

Thank you. Your partnerships?

Sanjiv Lamba:

Right. Let's talk about partnerships a little bit. The way at Linde, we think about partnerships, Bob, they fall into three different categories. The first is a technology partnership. A partnership where we are working with somebody to either scale up or develop a new technology that we know will further the benefits and the usage of clean hydrogen. A good example of that is ITM on the scale up side. Working with ITM, who've likely got the best PEM technology in the world today with the only Gigafactory available in the UK today, we are working closely with them to make sure that we are helping them scale up, so that we can get to that... From the two megawatts to the five, 10, 20 megawatts. And ensure that the technology package that we have is robust, it's high reliability and is out there to be able to be scaled and executed as we move forward.

The other and technology is Daimler. We're working closely with Daimler on the development of this liquid fueling system that we just spoke about a few minutes ago. Again, that's kind of the technology angle where either we are supporting scale up or we are supporting development innovation of new technologies that'll further the use of hydrogen in some shape or form. The other way I think about partnerships is at Linde we want to look at markets that we either want to get into, penetrate or get access to certain products, input products or feed stock, if you will. Our example of South Korea is a partnership where we went in with Hyosung, one of the larger local conglomerates over there. Working closely with them to take their low carbon intensity hydrogen, put it into the liquefaction. Put the liquefies on the ground, make sure we build infrastructure necessary for hydrogen fueling and tying the bus network in South Korea.

Exciting project for us, we see this as a first step. I'm hopeful that we will see the next couple of phases beyond where we are today. And again, that was a partnership that was meaningful because we were able to work to get access, not just to a particular market element, but also to access to the feed

stock, combining with both of those and bringing them together. That's an example where that has worked and, and is working very well.

The third type of partnerships that we focus ourselves on is complimenting each other on, on technical capability. A great example of this is sequestration and storage, right? Our view very clearly is that we have great knowledge, expertise, technology solutions on the capture side, but we recognize our limitations and recognize that on sequestration and storage. We need to bring a capable partner in. A number of partnerships that we've developed in that space are progressing really well. I'm pleased to see, really, are around making sure that we can complement and create an overarching solution around carbon capture in some cases use and storage stroke sequestration as well. That's a third type of partnership that just gives you a flavor of how we bring it together.

Now, I've taken some very high level examples. There is a whole range of partnerships that we currently have in place. I've said this before, Bob, for hydrogen landscape to develop and get the momentum it needs, partnerships will be a way, a crucial part of that development to build that momentum, really. And again, I think at Linde, we've been leveraging that actively. Our belief is, whether we do a project in a different market... Oman is another example of that, where to get access to the market, we worked with local partners, try to bring the offtaker and make sure that there was a technology partner on the storage side to bring it all together, to make something meaningful out of it. Or in the case of green projects, make sure that there's a renewable energy company that's part of that partnership to make sure that you have a viable and feasible project that comes out of that.

Bob Koort:

Sanjiv, do you feel government subsidization or regulatory prompts are necessary to get this evolution to the decarbonized world in green hydrogen? And maybe, what you see there?

Sanjiv Lamba:

Bob, if... Let me kind of take a step back for a moment and just talk about things that I think are important for the further development of the hydrogen space, right? To be honest, the commitment to decarbonization, the commitment to climate change is one of the key underlying principles, which is driving the clean energy space and its development and hydrogen as a consequence of that. Everything we hear and talk about at the moment, whether it's COP26, et cetera, all of that is moving that in the right direction.

But for growth to be sustained in that space. And I've said this before, so the risk of repeating myself, three things need to happen. The first that we need, policy and regulatory frameworks to continue to support this development. I'll dwell on that a bit more to answer your question more, more specifically. But for me, that's one of the key elements, a key trigger for this market to really get to its full potential. Second, you need technology movements to happen. The technology roadmaps to be in place that ensure that this economic gap between fossil fuel and clean hydrogen is minimized. For momentum to build up and for a point of inflection to happen, ultimately, economics need to drive that. Purely subsidies will not do that. For long term sustainable development, you need a technology roadmap that gets green and in the interim, blue, to a point of being highly cost competitive and, and being at a point where that momentum and inflection picks up. But these two are not sufficient.

The third piece is really around development in technology for the use of hydrogen. It's great if we have great government sponsorship and we have great technology roadmap and a cost effective hydrogen molecule, but you don't have an end user. If you don't have the developments around the OEMs and the liquid fuel we talked about as an example, to get that scale up we need, clearly you're

being held back. Because, hey, we've got everything in place, but the end use demand isn't quite where it needs to be.

Similarly, other industrial usage, which is obviously going to get supported and pushed, if you will, by regulatory actions, but really needs to develop technology to be able to absorb that hydrogen, and steel making as an example. That's where a bit more work around the technology is being done. Again, we are doing a lot of that work with many, many large steel makers in the world. Again, pleased to see progress over there, but really you need to get to a point of inflection where widespread adoption can happen. Those three factors in my mind, those three key triggers, really creates sustainable change and a sustainable movement in that direction.

Let's talk about the government subsidies there. My view is you absolutely need government subsidies today, to ensure that the infrastructure and ecosystem necessary for hydrogen to be used as a fuel, whether it's mobility or industrial applications is there. Without that... I talk about regulations with teeth. It either comes in the shape of a price that you pay and that hurts, so that you do something about it or an incentive that pulls you and says, "Well, yeah, we are going to do something about this because you know what? There's an opportunity over here for us to create some economic value as a result of this". Both of those elements, sometimes, a combination of those as well works, needs to be in play. Government subsidies today and for much of this decade will be a necessity as we build this infrastructure up, to ensure that you have then the transition to a cost effective, long term, sustainable fuel as part of the broader fuel portfolio.

I'm not suggesting that hydrogen will be the only kind of fuel element of the future. I think you will have a basket of energies in that portfolio. But hydrogen, for it to play a meaningful role, does need that support from the government. And I'd say to you, if I look in the US today... We've been pretty upfront in telling the government as well that the 45Q is just not good enough to put that momentum. That 45Q in our reckoning anywhere between \$85 to \$110 per tank is really where you will start seeing economic cases and incentive for greater action to happen more broadly in that space.

In Europe, clearly, the ETS is moving forward. You can see it priced, today, I think anywhere between €60 to €65 a ton. You see in Netherlands as an example, the SDE++ is adding another significant cost on top of that. That is spurring many companies and industries in particular, for whom it starts becoming an existential challenge if they don't do something about it. And it's spurring action in that area. We think that that's in the short term. These are measures that do help, whether it's incentives or pricing and penalties, the combination of that works very effectively, create the momentum needed to get us to a point where I think it's meaningful.

Bob Koort:

Sanjiv, Juan, unfortunately, our time is already up. We've got plenty more to chat about here. That's obviously a very exciting topic for yourselves and for the investment community. Really appreciate you taking the time here and we'll be watching closely as you evolve your hydrogen strategy. Thanks so much.

Sanjiv Lamba:

Thank you,

Speaker 3:

Bob, thank you.