HydrogenNowCast Episode 83 – HyET Hydrogen

[00:25] **Brian:** Well, hello, everyone, and welcome to the HydrogenNowCast for February 23, 2024. I'm your host, Brian DeBruine, the director of the non-profit Colorado Hydrogen Network. This is a podcast devoted to encouraging the deployment of hydrogen infrastructure throughout the world. Our intent is to encourage and motivate others to take charge to help deploy hydrogen as a means to decarbonize the transportation and other energy sectors and to accelerate the movement to stop climate change.

Well, on the podcast today, we're going to hear from the company HyET Hydrogen, who makes electrochemical hydrogen compressors and electrochemical hydrogen purifiers. And to tell us all about the technology, the products, and the company is Quinten Swanborn, who's the head of business development at HyET Hydrogen. Quinten, welcome to the show.

[01:14] **Quinten:** Thank you very much, Brian. Honored to be here. Thank you very much for the interest in the technology and looking forward to discussing our electrochemical hydrogen compression and purification, but also separation technology with you.

[01:26] **Brian:** Excellent. Well, so happy that you could spend a little time with us today, Quinten. Listeners, this is actually the second time that I've had HyET on the podcast, but the first time was way back in Episode 8 on August 19 of 2020. But I thought it was worth having HyET back on the show to talk about how the company and the products have evolved. Plus, we're seeing a lot of interest in natural hydrogen wells, (which, in fact, was the subject of the last podcast.) And HyET's purification technology is really useful to separate hydrogen from other gases that typically come from these wells. So, Quinten, why don't we start with you telling us a bit about HyET, the company, and the business in the Netherlands and the US for sure.

[02:09] **Quinten:** So HyET, the headquarters is based in the Netherlands in Arnan. HyET stands for high yield energy technologies, and we're focusing with HyET on the entire energy transition landscape. So HyET Hydrogen is one of the three main technology portfolio companies that HyET has. What the mission of HyET is to accelerate the energy transition. We do that both in the field of hydrogen generation, but also transportation and storage and partly in the end use side as well. We have a technology for generation of renewable power, thin film amorphousilicon solar panels. That is how HyET originally started out. HyET hydrogen was later added to that. And then we have a newer company, HyET Clean Energy Solutions, that also has technologies in the lithiumion space, carbon capture space, and ammonia cracking space, as well as in the electrolysis space. So we have a broad portfolio. How we work generally is together with knowledge institutes and universities to bridge the gap between lab scale and commercial application, among which we work with the Colorado School of Mines. So because of that, we also have an office located in Golden, Colorado, where we run part of our operations from after we've gone through a small commercial scale. We generally use with large industrial players for the industrialization of the equipment by leveraging their manufacturing capabilities, their supply chain and sales channels. So example, for HyET, hydrogen is Baker use. We recently announced a partnership with them in which we do a joint market approach in getting hydrogen compression technology to market.

[03:51] **Brian:** All right, well, thanks, Quinten. That's really impressive, all the things that HyET is doing. But why don't you tell us a little bit about yourself, your career, and what your interest is in hydrogen and what you do for HyET.

[04:04] **Quinten:** So I'm an industrial engineer by trade, specialized in renewable energy. Right after my studies, I also did some work at NREL in the thin-film solar panel space, so also for HyET. And later went a bit more towards the hydrogen space where I've been working in the past couple of years, where my passion for that started.

I'm a big nature enthusiast, love everything outdoor. That's why I did some work in Colorado, to experience the Rocky Mountains there. And I've been raised with the idea that we need to ensure that generations after us can experience the nature same way as we can. And big part of that to me is decarbonizing, and I see a lot of potential for decarbonization, especially in the renewable energy space.

The more we move to a renewable energy landscape, the more buffering of energy will come into play, since solar and wind produce at moments that energy is available, not necessarily when energy is required. And hydrogen is a key piece in there in order to store energy for longer periods of time and transform it back to power at the time it is required. So that is why I started working more towards that hydrogen space within HyET hydrogen. My role is head of business development, and I interface a lot between market and technology. So we don't have a catalog product. What we have is technology solutions that can fit different types of use cases. So big part of my role is scouting the market, see where we have good propositions versus traditional alternatives, and then find strategic partners in order to get the technology to the right scale for commercial operation.

[05:43] **Brian:** All right, well, thanks, Quinten. I guess I didn't realize that you had spent time in Colorado, so that's excellent. Glad to hear that.

So, you alluded a little bit to some of the business aspects of things, but why don't we start out talking about the technical aspects first? And probably the best place to start is why don't you explain really what an electrochemical compressor is, and contrast that with mechanical compressors like piston or diaphragm.

[06:09] **Quinten:** What mainly distinguishes our technology is the fact that we don't have any moving parts. So, mechanical compressors achieve pressurization of volumes by physically compressing that gas. We work through another principle, an electrochemical working principle, which implies that we transport hydrogen over a membrane in the form of protons, which is much like you see for PEM electrolysis, for example. The type of technology is quite similar.

So, the way our electrochemical hydrogen compression process works is low pressure hydrogen enters the equipment. We catalytically split up molecules of hydrogen into protons and electrons, and by applying power, we can circumvent the electrons to the other side of the membrane, which causes a potential static difference between inlet and outlet and drives protons from one side to the other. The amount of power required to drive that process is dependent on how low your inlet pressure is and how high your outlet pressure is. So the bigger that difference, the more energy it will take in order to drive those protons through the membrane.

[06:45] **Brian:** Okay, well, thanks, Quinten. You were comparing the electrochemical compressor to an electrolyzer, and listeners will see this if they go to the HyET website, which is hyethydrogen.com. But the stack for the compressor and a stack for a electrolyzer and a stack for a fuel cell look very similar. And I think even if you're an expert, without the balance-of-plant around those, you'd be hard pressed to tell the difference.

[07:12] **Quinten:** Yeah. So for the difference between electrochemical compressor stacks and electrolysis stack, what's the main difference? You'll see is that our compression stacks are round. They have round active areas because they are made for pressure containment. Electrolysis stacks can be round or square, usually square, because the surface utilization of material in production processes is a bit higher, and they don't need to withstand that same type of pressure.

[07:37] **Brian:** All right. Thank you. Well, why don't we talk about how the energy consumption and the cost of an electrochemical compressor compares to mechanical compressors.

[07:47] **Quinten:** That is very much use-case-driven compression processes. They can have quite a lot of parameters influencing the type of design. So inlet pressures, outlet pressures, flow capacities, et cetera. For mechanical compressors, there's a sweet spot. And for electrochemical compressors, there's a sweet spot as well.

So what works best for mechanical compressors is high flow rates, low compression ratios, and quite consistent flows of gas. For our side, we operate better at high pressure differentials. We can also do low pressure differentials at intermittent operations and smaller flow volumes.

So if we take 0.1 bar – or slightly overpressure above atmospheric – to 200 bars, as an example, we could do that with a single stack. But with a mechanical compressor, you can consider about a compression ratio of factor two per stage. So you would need a lot of stages in order to get from that atmospheric pressure to about 200 bars, which, in turn, you need a lot of interstage cooling, quite some equipment. So the energy efficiency and the capital costs for such a system are higher than our single stage solution.

However, if we start looking at 100 bars to 200 bars, for example, mechanical compressor can do that in a single stage, very simple system. If we look at our technology, the stack will exactly be the same as for the atmospheric to 200 bars gauge, because we still need the same amount of membranes, those membranes can do a high pressure differential. You can also use them for a lower pressure differential. But your competitive benchmark that you're competing against in mechanical compressors, then, is a lot more effective. So there is a bit of tradeoffs to be made, of course, with regard to the type of use case, which technology would be best suited?

[09:34] **Brian:** Well, Quinten, what are some of the other use cases for the electrochemical compression?

[09:39] **Quinten:** So, some of the main use cases are direct coupling to electrolyzers. You'll see now that a lot of green hydrogen projects are being built for which electrolyzers are coupled to renewable energy sources, which causes fluctuations in hydrogen. We can very flexibly turn down the volume of compression for our compressors, which also, if we operate below nominal, increases energy efficiency. Plus, we require humidified hydrogen to run our process, which is supplied by electrolyzers. So we can tune very well to the outlet flow of electrolyzers to, for example, then inject hydrogen into pipelines or pressurize it for industrial purposes.

Something else which leveraged the unique characteristics is purification of hydrogen from dedicated pipelines. So, dedicated pipelines will be used to transport hydrogen, which doesn't provide completely pure hydrogen that will be 98% pure. We can compress from pipeline pressure to desired outlet pressure. So, for example, a refueling station, and then at same time, purify it to fuel cell grade.

And another type of use case is hydrogen release processes. So, for example, the release of hydrogen from ammonia or liquid organic hydrogen carriers, the process pressures of those release processes are generally very low and contain some impurities. So there we can also do single stage compression and purification.

[10:59] **Brian:** Okay. All right. Well, thanks, Quinten. Well, because electrochemical compressors allow only hydrogen protons to pass through the proton exchange membrane, or PEM, that would mean that any impurities, like oxygen or water, would be filtered out. So, electrochemical compressors purify hydrogen just by the nature of their operation. But HyET also has a distinct product to separate hydrogen. Why don't you tell us a little bit about the electrochemical hydrogen purifiers and about the benefits of electrochemical hydrogen separation equipment. Yeah.

[11:35] **Quinten:** So, indeed, as you rightly mentioned, with our compression equipment, inherently, we do some purification because we split up the hydrogen into protons. Those protons pass the membrane and then recombine as molecules. We can filter out, so to say, contaminants that may be present, since they will not catalytically react to protons and then pass the membrane to the other side. And we use that equipment if quantities of hydrogen are relatively high and you have a bit of impurities in there.

However, if you go to the scenario where you have, for example, 5% of hydrogen in your feed and you enter that into the compression stacks, that would block the active area, and we need to intermittently purge that. So we started out with the compression equipment, but we did get a lot of inquiries on having lower quantities of hydrogen as well, in bulk volumes of carrier gases. So, for that, we designed a different piece of equipment, which is more similar, like a fuel cell stack. It's also square, not made for pressure containment, but mainly for energy, efficiently and cost effectively separating out hydrogen at equal pressure, which uses the same type of membrane material, the same working principle.

So, again, we split up hydrogen into protons, which can pass the membrane, but without a pressure differential. We use a different type of configuration for those types of systems as well. So those we place in a pipe-spool with a series of stacks behind each other, and the gas can freely flow between the cell plates. So you get a certain gradient of hydrogen in your flow, which is higher at the inlet of the pipes pool and lower at the outlet of the pipes pool, with which you can tune a separation rate of hydrogen.

Now, that is quite unique compared to traditional separation equipment, because there, you cannot really tune your recovery rate of hydrogen. What you will get, especially for Pressure Swing Adsorption, is the purer you need the hydrogen to be at the outlet, the more hydrogen you will lose.

For our technology, we separate out hydrogen to the required amount, for example, and application, or even separate out all of the hydrogen, and the rest of the hydrogen remains in the retina gas and remains flowing in the carrier gas stream. So with that, we minimize or actually avoid hydrogen loss in that process.

[13:51] **Brian:** Okay, well, I'm kind of wondering what some of the other key use cases would be for electrochemical purifiers. I mentioned hydrogen wells and needing to separate gases out. But I'm also thinking about things like recovering hydrogen from a mix of hydrogen and methane, say a natural gas pipeline. So what are really some of the key target uses or use cases that you see for the electrochemical purification?

[14:15] **Quinten:** So for the blending equipment or the separation equipment at lower quantities of hydrogen blending, de-blending in the natural gas grid, that is one of the major use cases. So you can inject hydrogen into the natural gas grid, use that bulk volume of natural gas to transport that hydrogen, and then separate it out again at an endpoint, it's something that we have demonstrated with SoCalGas as well in California.

But there's also industrial applications, such as the recirculation of hydrogen. You get some industrial processes that produce hydrogen as a byproduct, semiconductor processes, for example, where you get hydrogen and nitrogen blends. With our technology, we can separate out hydrogen from that nitrogen and recirculate it back to the initial process.

And as you mentioned, natural hydrogen reserves, where you get blends of helium and methane and nitrogen, for example, in there as well. We can use our technology very well to purify and use that hydrogen again.

So I mentioned before that the separation equipment can be used to tune recovery of hydrogen, and that avoids losses. But with traditional types of separation methods, they mainly rely on the molecular size or weight of components. And if you're looking at mixtures of hydrogen and helium, for example, it becomes very difficult because helium and hydrogen have quite the same characteristics. Still, even at those types of specifications, we can separate out hydrogen because we transfer it into protons, pass that through the membrane, and the helium stays behind to achieve efficient separation.

For traditional technologies, often also you create a pressure drop, since you are, for example, for membrane, traditional separation membranes, you create a pressure differential, which causes it to filter some of the molecules, but your carrier gas will lose pressure in that process as well. So if we consider a deblending case of hydrogen and natural gas, it implies that you would need to recompress your entire carrier gas flow as well, which is a very expensive process.

[16:12] **Brian:** Okay, good. Well, thank you. Why don't we switch back to talking about the compressors again? And I'm wondering about the size of the plants. Not just physical size, but also the hydrogen capacity. The 700 bar piston compressors that I've seen are as large as a motorcycle and contain a huge amount of metal. But talk a little bit about the physical size as well as the hydrogen capacity for the compressors. Yeah.

[16:38] **Quinten:** So what now is a standard design? From our side is a two ton per day system which fits in a 20 foot container now working towards a ten ton per day system in a 40 foot container. If you compare that to mechanical compressors. So, for example, an atmospheric to 200 bar mechanical compressor at ten tons per day would be about 250. Technology will fit in about a 10th of that. So the main part for that is because we are not volume driven, we are mass flow driven. We don't need to mechanically make an entire volume smaller. With that electrochemical process, we can operate at relatively smaller equipment volumes than mechanical compressors.

[17:21] **Brian:** Interesting. I didn't realize there was such a big size differential, so that's really good to hear. Well, why don't we switch from talking about the technical aspects to more of the business aspects of HyET's products? So where do HyET's compressor and purification products stand in the development and the production cycle?

[17:40] **Quinten:** Yeah, so that differs per application. We already have commercial products up and running in the field, but especially on purification projects, the type of equipment that we deliver depends on use case specifications. So inlet pressures, outlet pressures, flow rates, hydrogen purity at the inlet required, hydrogen purity at the outlet, et cetera. So our general procedure in validating that technology. So, since it's a modular technology, we can, at a small scale, do a proof of principle and confirm performance criteria to see how that matches customer use cases so often. First do a confirmation test at a very small capacity of hydrogen, then do a pilot or demonstration project to get it at an actual site in the field and run some tests on it, and then go to a commercial stage. So we have different types of applications in different stages along that scale up.

[18:34] **Brian:** Okay, well, thanks, Quinten. So you already mentioned that HyET has their headquarters in the Netherlands, and you have an office here in Colorado and are also doing some work with SoCal gas in southern California. But could you talk a little bit about where some of the HyET compressors are already in use throughout the world?

[18:53] **Quinten:** Yeah. So in different continents, I think, almost all continents operational in the US, Australia, Europe, in Asia, and types of applications that they're running at, for example, in the defense industry. So, replacements for diesel generators, those are systems that generate power using solar. There's a small electrolyzer in there to turn that power into hydrogen. Our compressor is used to compress that hydrogen for storage, and then there's a fuel cell to, again, generate electricity from that hydrogen when that is required. And why that is specifically interesting for military is because it doesn't make sound. Cannot place a diesel generator everywhere where you might want to be a bit more silent. But other applications, industrial hydrogen recirculation processes, but also building heat and power applications, which is the same type of systems that I mentioned for the defense industry, but then for residential purposes. So, especially in areas in the world where seasonality is a bigger factor, storage as hydrogen generated in summer to be used over the winter, is something that our equipment is being used for.

[20:00] **Brian:** Well, that's interesting. You mentioned the sound that the military is concerned about, and I could see that being the case for, say, a neighborhood hydrogen fuel station where you're doing compression and you may be concerned about noise. So that's another interesting aspect.

Well, Quinten, this has been a really great discussion. I would encourage listeners to go to the HyET website to learn more about the compressors and the purification. And the website is hyethydrogen.com. That's hyethydrogen.com. And of course, they can put requests in for more information. But if listeners wanted to reach out to you. What's your email, Quinten?

[20:38] **Quinten:** My email is quinten.swanborn@hyet.nl. And maybe good, Brian, to include it in the description of the podcast. I might not have the easiest name.

[20:51] **Brian:** Yeah, I will. I'll put that into the show notes. Well, is there anything that we haven't talked about that you'd like to add? Yeah.

[20:59] **Quinten:** So maybe also to inform listeners, we've gone over a couple of use cases for our technology. But as mentioned, our technology is very flexible to fit to certain types of use cases. So in case you're working on hydrogen processing, both on the compression or purification separation side, you're struggling to get the right kind of equipment to be used for your processes. Feel free to reach out. I would happily set up a bit of use case study, some costing, to see how our technology could potentially make a difference.

[21:31] **Brian:** Okay, well, thanks, Quinten.

Well, listeners, I've been talking with Quinten Swanborn, who's the head of business development at HyET Hydrogen. Quinten, thanks for your time to be with us today.

[21:41] **Quinten:** Thank you very much for having me, Brian. Very much enjoyed the conversation. Wish you all the best and hope to see you in person in Colorado someday.

[21:49] **Brian:** Yeah, well, if you're a skier, let me know when you're in town. We'll go hit the slopes.

[21:53] **Quinten:** Sounds good.

[21:54] **Brian:** All right.

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