Steps to capture economic viability

SES, a **Chart Industries** company, says its Cryogenic Carbon Capture™ technology is ready for commercialization

By **Nick Parkinson**

When Elon Musk revealed details about a $100m prize for innovators who aid the development of carbon dioxide removal technologies, it created some interest at Sustainable Energy Solutions (SES) for a good reason.

"When we heard about that we said we should send him our address so he can send us the check because we've already done it," Andrew Baxter, CEO and President at SES, told **gas**world.

Musk's $100m challenge came a month after a significant development for SES, which was acquired by cryogenic equipment manufacturing giant Chart Industries for $20m plus earn-out considerations in December. Musk is looking for innovators to prove they can cost-effectively scale their technology to a level that exceeds anything that has ever been built before. Musk's Xprize is more focused on CO_2 capture from the atmosphere. While SES' technology is theoretically capable of direct air capture, its near-term focus is on capture from more concentrated point sources.

"Capture from concentrated point sources is both more energy efficient and cost effective than capture directly from the atmosphere and represents a nearer term market," Baxter said.

SES believes its partnership with Chart has bolstered its chances of successfully commercializing its cryogenic carbon capture system, which separates a nearly pure stream of carbon dioxide (CO_2) from power plant gases.

"The timing of partnering with Chart is all about that transition of going from research and development to commercializing the technology," Baxter said.

But commercialization has so far been elusive for carbon capture, as the technology has been too expensive and energy intensive for captured CO_2 to be sold for profit. With the maturity of regulatory frameworks and carbon taxes which can incentivize carbon capture on a large scale, is now the time for carbon capture to gain some commercial traction?

© **Chart** | A Chart brazed aluminum heat exchanger

Proving a point

SES's Cryogenic Carbon Capture™ (CCC) technology eliminates most emissions from fossil fuels while enabling better use of intermittent renewables through grid-scale

energy storage.

The system was invented by Larry Baxter, Andrew's father and a professor of chemical engineering at Brigham Young University, who had his lightbulb moment while on a visit to oil and natural gas conglomerate DONG Energy [now Ørsted A/S] in Denmark in 2007. Its CEO told Larry if there were two things he could have for Christmas it would be a more efficient way of reducing emissions from their fossil fuel power plants, and a better way to utilize wind power on their grids. It got Larry thinking how to do both those things at once. A year later, he co-founded Utah-based SES with Andrew and the company has since demonstrated its CCC technology with several pilot programs.

"We have developed this technology from an early concept, gone through the hard work of proving this can work and proven it in the field several times at a coal-fired power plant, demonstrations at cement plants including a combined demonstration with CarbonCure," Andrew said.

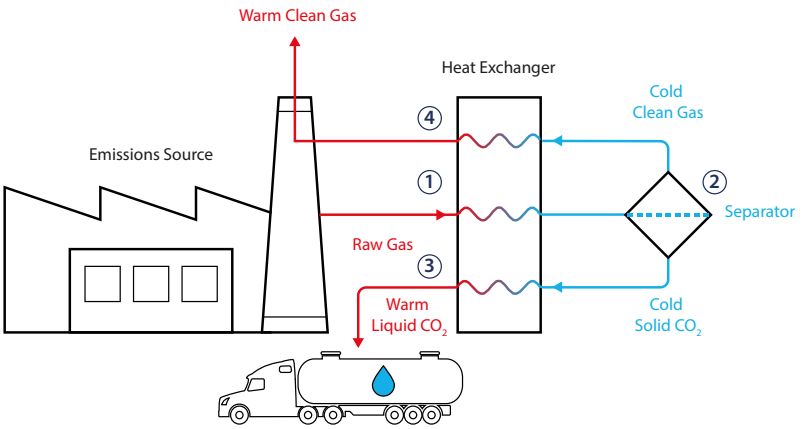
"We have got it to the point where we believe we have a design that is ready to scale, we have done a lot of the technical de-risking, we are ready to transition from development to commercial mode."

SES's system works by cooling down the gas until the CO_2 freezes solid, when the system separates CO_2 from the gases that are in the exhaust streams. It is done in an energy efficient way by heat integration *(see Figure 1)*.

"We take the warm stuff going in, we cool it down to the point where the CO_2 freezes but then we turn around the CO_2 and gases and warm them back up so what's going in our process and coming out of our process are about the same temperature," Andrew said.

"Because of that we are able to recover most of the energy we put into cooling the gas down."

Figure 1. Cryogenic Carbon Capture (CCC)



The CCC process (1) cools a dirty exhaust gas stream to the point that the CO_2 freezes using mostly heat recuperation, (2) separates solid CO_2 as it freezes from the clean gas, (3) melts the CO_2 through heat recuperation and pressurizes it to form a pure liquid, and (4) warms up the clean, harmless gas releasing it to the atmosphere.

Source: SES

Coupling SES's CCC technology with Chart's air-cooled heat exchangers, brazed aluminum heat exchangers, IPSMR® refrigeration/liquefaction system and cryogenic storage and transport equipment has created a one-stop full solution option for those looking for integrated technology and equipment.

"We have been working with Chart for years as a key supplier for a key piece of the process that makes the cooling work," Andrew Baxter said.

"Their brazed aluminum heat exchangers are world leading, and in partnering with Chart we have significantly de-risked that key part of the technology. The CCC technology also uses a single-mixed refrigeration process very similar to the one used in Chart's leading LNG system called IPSMR® Process Technology. Taken together – those multi streamed heat exchangers and those refrigeration systems – make up the majority of the capital cost for our system and now we have brought together the process technology with the equipment provider to bring a full solution to customers."

At the CarbonCure demonstration in Alabama in 2018, CarbonCure took CO_2 captured by SES at a cement plant in the Atlanta area and used it in concrete production at a commercial construction project near that same plant. SES's longest testing has been at coal-fired power plants in Wyoming and Utah, and it currently has a small pilot plant being demonstrated in Saudi Arabia. Larry believes such vigorous testing puts SES's CCC system ahead of other carbon capture technologies.

"One of the unique characteristics of this process which has been tested in the field on coal-fired power plants, cement plants, and exhaust gas from fuels including natural gas, biomass, shredded tires, municipal waste, and coal, is it's probably the broadest fuel tested technology of any of the developing

© SES | Cryogenic Carbon Capture small pilot as tested in the field

technologies that there is," Larry Baxter told gasworld.

"This technology is an easy retrofit technology, it's one of its advantages. You can bolt it on to existing systems and you don't need significant new infrastructure in place for it or to modify the upstream process. Part of the challenge is that there just hasn't been a good solution to carbon capture. The solutions people have proposed have been extremely expensive and energy intensive so people have been reluctant to go for carbon capture. Our technology has been successful at doing so many field tests because we are almost invisible to the people on site, it doesn't disrupt their process at all, so I think that has helped our technology a lot."

Cool technology

Chart, with its experience of storing and transporting CO_2, has a growing pipeline of carbon capture and direct air capture commercial opportunities for 2021 and 2022, and in February announced a $15m investment in Canadian company Savante Inc. Whether it's for use in enhanced oil recovery, conversion to fuels or fertilizers, greenhouses, to make dry ice, pH-control, carbonation of beverages, and food storage, there are various applications captured CO_2 could be used for.

> "Commercialization has so far been elusive for carbon capture, as the technology has been too expensive..."

"Uniquely, the CO_2 that comes out of our systems is a high purity liquid ready for use and transportation and storage," Andrew said. "The product that goes in Chart tanks and Chart piping is what we produce and Chart has great relationships with the distribution channels and customers."

SES is pursuing its first small commercial systems which are capable of 30 tons per day liquid CO_2 production, up to 400 tons per day.

"That's our next step and we are pursuing several promising projects which are in their early stages," Andrew Baxter said. "This year we will be getting those under way. We are producing CO_2 for existing CO_2 customers who are using it for emerging utilization and conversion processes, food and beverage, industrial uses, and they would be in that range of what we are ready to tackle."

LNG plants are another possibility.

"Anybody that is doing LNG and interested in reducing their carbon footprint should definitely be looking at this technology because you have already got most of the carbon capture technology built by the time you have got your LNG plant," Andrew Baxter said.

Chart is well positioned in the LNG market and Curtis Stubbings, Vice-President, Specialty Markets at Chart, told gasworld, "One of the unique aspects to this CCC technology is that it produces a high purity CO_2 liquid really for no significant added cost where as if you took some of the competing technologies they are not necessarily high purity or a liquid. If you are going to sequester the CO_2 or use it for enhanced oil recovery it's much less expensive to pump a liquid up to a high pressure for that application than it is to take a low pressure gas and compress it up to those pressures, and that's another advantage of this technology. CO_2 is also a great fit for water treatment, and we are seeing more and more applications for CO_2 for pH control using other Chart equipment."

Making carbon capture a commercial success is what Musk, the Tesla CEO and billionaire tech entrepreneur, is looking for. "What Elon has talked about, is negative emissions and we can achieve negative emissions at point source capture costs," Andrew Baxter said. "A unique benefit of the SES technology is the ability to capture more than 100% of the CO_2 created in the combustion of fuels at a point source – i.e. power plant or industrial plant – so that all of the CO_2 created by the point source is captured in addition to some of the CO_2 in the atmosphere resulting in a carbon negative process."

Stubbings added, "We use the cryogenic carbon capture to recover all of the CO_2 from combustion but you still have about 400 ppm that's coming in from the air and we can design the system so you get most of that CO_2 too, so it's removing CO_2 directly from the atmosphere." gw