

Capturing carbon's potential: Five companies and innovations to watch

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A semi-trailer is idling just outside Enmax Corp.'s Shepard gas-fired power plant on Calgary's eastern outskirts, and it is loaded with a grey granular substance that's become Apoorv Sinha's life's work.

Mr. Sinha's startup, Carbon Upcycling Technologies, has invited business partners and government officials to have a look at the reaction vessel that yielded the powder from the plant's waste carbon dioxide, and then watch the 40-tonne load trundle away to a concrete batch plant in Edmonton.

His team manufactured the additive from the greenhouse gas that otherwise would have been emitted into the sky. Lafarge Canada will add the powder to its concrete mix in place of some of the portland cement it normally uses, and lower emissions from making its own products.

"There's no doubt we've come a long way, but to really make the impact that we're striving for we've got to change behaviour. The aspiration here is that we start with this Western Canadian business unit, then Lafarge all across the world starts to change how they do business," said Mr. Sinha, a 31-year-old entrepreneur who has been Calgary-based Carbon Upcycling's chief executive officer since the technology was first proven in a reactor the size of a cookie tin six years ago.

Carbon Upcycling is in a fast-growing segment of the Canadian cleantech sector focused on manufacturing useful products and providing innovative services by tapping into the massive volumes of CO₂ captured from all kinds of energy and industrial processes to reduce the impact on climate.

A spate of technological developments in the fields of chemicals, manufacturing and agriculture has caught the attention of environmentalists, scientists and venture capitalists alike, as companies tout new uses for the heat-trapping gas that would otherwise be spewed into the atmosphere, injected underground or used to boost oil production.

Of course, there is also a phalanx of environmentalists who are wary of carbon capture, saying the practice will prolong the use of fossil fuels, which they contend must end for the world to get to net-zero emissions.

Even so, the business opportunity looks huge. The U.S.-based Global CO₂ Initiative has estimated the market will be worth as much as US\$800-billion a year by 2030, and Canadian entrepreneurs and scientists are already making their mark.

In April, another company focused on lowering concrete's carbon intensity, Halifax's CarbonCure Technologies Inc., won part of the US\$20-million Carbon XPRIZE, a nearly five-year competition sponsored by Canada's Oil Sands Innovation Alliance and U.S. power company NRG Energy Inc. The next phase of the technological race has a US\$100-million purse, and is sponsored by Tesla Inc. founder Elon Musk and his foundation.

Other major tech players, including Canadian e-commerce giant Shopify Inc., have dedicated funds to find solutions to the carbon conundrum.

The trick for developers will be proving they can scale up and commercialize their innovations – sell them in industrial and consumer markets at a profit – so they will attract investors and make a real difference in the fight to limit greenhouse gas emissions.

Here are five emerging Canadian companies with carbon utilization technologies that could be on the verge of major market breakthroughs.

CARBONOVA CORP.

CALGARY

Under an electron microscope, the carbon nanofibres Carbonova produces at its lab at the University of Calgary look like tangles of ramen noodles. To the naked eye, they are a black powder, one that stands to revolutionize everything from construction materials to car parts to electronics because of an unusual combination of strength and light weight.

Carbonova's secret lies in the science of how it produces the material from carbon dioxide and an even more potent greenhouse gas, methane, using two catalysts to trigger chemical reactions. It is the brainchild of CEO Mina Zarabian and chief technology officer Pedro Pereira Almao.

When the pair, experts in catalyst research, developed the process that spit out the material in 2016, they were elated. But celebration was tempered somewhat by skepticism among other chemical engineers, used to coke being the cheap byproduct of such a reaction, not a sought-after material used in the most advanced manufacturing, Ms. Zarabian said.

“Although it looks the same – it’s black and under analytical equipment it says it’s carbon – when you put it under a microscope, you see it’s a different type of carbon. Carbon can be formed in many different ways,” she said.

The energy-saving process and its potential have caught the attention of investors, including well-known names in Canada’s oil patch: Pat Carlson, former CEO of Seven Generations Energy Ltd., and Perpetual Energy Inc. CEO Sue Riddell Rose. Carbonova fields frequent calls from large CO₂ emitters.

The real test, however, will be producing enough of the product for global markets, and at a low-enough cost, to realize its benefits.

“You can use it for so many things. The reason we cannot use it at this point is that it’s too expensive,” Dr. Pereira, who is also a professor at the university, said during a tour of the research facility. “So we’re going to make it less expensive but also available for everybody, while we reduce, considerably, the environmental impact – the process for producing carbon nanofibres.”

Carbon nanofibre is prized for strength and versatility. They are 40 times stronger than steel and a quarter of its weight. The material can be used in paints, electronic components, metal and plastics. It is also more electrically conductive than copper.

Today, global production of carbon nanofibre and nanotubes, at less than 5,000 tonnes a year, is dwarfed by carbon black, at 14 million tonnes, and standard carbon fibre, at 150,000 tonnes.

Carbonova is now scaling up, having recently completed a \$2-million financing round. It is also part of a Canada-U.S.-European consortium that will study the development of products for the building and automotive sectors over the next three years, on behalf of a multinational company in the construction sector looking to reduce its carbon intensity.

Its customer’s tests have yielded positive results, but it wants more volume. Now, Carbonova is building a reactor it describes as “semi-commercial’ in scale that will yield 150 times more than the bench prototype.

Once the pilot proves itself, the goal is to build modular plants at a cost of \$20-million to \$30-million each that can produce thousands of tonnes a year. The plants will be designed for sites where there are emissions to tap and proximity to end users of the carbon nanofibres, Ms. Zarabian said.

The founders hope to keep the company and its intellectual property in Canada, especially the West, but Ms. Zarabian is cognizant of how difficult that can be as a startup tries to scale up, a frequent worry in Canadian tech. “Business sometimes is a race,” she said.

CO2 GRO INC.

TORONTO

CO2 Gro Inc. has been on a long road with its technology for improving the use of greenhouse gas in greenhouses. The founders' initial plan more than a decade ago was to capitalize on keen interest in algae for biofuels. It had success in the lab at the National Research Council Canada in Halifax, and launched an initial public offering.

As oil prices surged to US\$147 a barrel in 2008, algae was seen as the next big thing. Then crude fell back to earth during the financial crisis, and the buzz died down. Algae no longer looked like a viable business, but the plant-growth technology would prove versatile.

Canada's legalization of marijuana in 2018 was the start of CO2 Gro's second act.

Pumping CO2 into greenhouses has long been known to increase plant growth by as much as 30 per cent, but the process is inefficient, and during hot months the gas gets vented into the atmosphere. CO2 Gro's technology involves infusing water with CO2, but in a way that does not yield club soda. The solution is misted onto plants in short bursts, improving the efficiency of the process.

The pot industry quickly became a top market, and now CO2 Gro has sold its misting systems to eight licensed cannabis operations. It is also concentrating on other crops grown in protected structures, including peppers and berries – those with large enough leaves for the technology to be effective.

“The use of carbon in most cases has not been a very precise thing. People burn fuels to make carbon, they do all sorts of things to get the CO2 for the carbon, and in most cases it's lost,” said John Archibald, CO2 Gro's CEO.

To pump the gas into a 100,000-square-foot greenhouse, an operator may have to inject up to a million cubic feet of CO2, he explains. In many cases, as much as 90 per cent of that then gets emitted.

“What we do is put the CO2 into the water at a specific solution rate, and put it onto the leaves in a mist so the leaves basically uptake nearly all of the carbon that we give them. So we use about 5 per cent of the carbon that somebody would if they were gassing,” he said.

The technology has also proven itself in another important way: It reduces the need for herbicides, because the solution alters the pH level on the surface areas of the leaves,

allowing the plants to resist pathogens such as E. coli, mould and powdery mildew, a common problem for cannabis producers.

“So a lot of folks look to us for the natural pesticide that comes part and parcel with putting on mildly acidic water loaded with saturated CO₂ molecules,” said Sam Kanes, the company’s vice-president of market research.

CO₂ Gro has 10 staff, and uses a global network of independent sales representatives to market its delivery systems. Its largest shareholder is U.S.-based private equity firm Ospraie Ag Science LLC.

In the past year, CO₂ Gro has signed several deals with companies around the world to determine the commercial viability of the technology in their operations. They grow crops such as lettuce, strawberries and peppers, as well as orchids and roses.

“We are seeing an average of 30-per-cent crop increases, and to generate those crop increases we’re only adding about 5 per cent of the CO₂ to the atmosphere,” Mr. Archibald said. “In a world that is experiencing food stresses to feed populations, particularly in the emerging economies that’s an important gain. We can’t work with wheat and we can’t work with rice, but we can make a significant contributions at the margin.”

CLEANO₂ CARBON CAPTURE TECHNOLOGIES INC.

CALGARY

Jaeson Cardiff is a plumber and gas fitter by trade who started his company, CleanO₂, developing technology to strip carbon dioxide from furnaces. Now he is marketing soap with natural ingredients to some of Canada’s best-known retailers.

The two go hand in hand. The reaction unit Mr. Cardiff invented removes carbon from the flue exhaust of commercial boilers, and using heat, the reactor produces potassium carbonate. The company mixes the white, powdery substance into its lines of soaps and cleaners, with benefits similar to a water softener.

The soap started as a novel marketing tool, but that changed quickly, as the company realized retailers and consumers liked the products.

“I had multiple conversations with Kathi Fischer, our chief science officer, saying something to the effect of, ‘We’re never going to be a soap company. I don’t want to be a soap company. We’re a carbon capture company. We will not make soap,’” Mr. Cardiff said. “Now we’re making soap.”

The liquid hand soap and body bars have names such as Wilderness Lager, Spearmint & Clay and Mulled Merlot, and the company produces car wash detergent.

“You’d have to be fools not to notice attraction of a product made from carbon that was sequestered from a heating appliance. And you have to be even bigger fools not to modify your business strategy to incorporate that,” he said in CleanO2’s fragrant East Calgary office and manufacturing centre.

Besides removing CO₂, the reaction unit, called CARBiN-X, also provides more efficiency to buildings by generating its own heat that can be used for water. A single unit, which is about the size of a couple of refrigerators side by side, removes six to eight tonnes of carbon per year.

Mr. Cardiff developed the first units 15 years ago for home use. The technology worked, but the business didn’t. The breakthrough came with the decision by the founders to increase the size of the reactors for commercial operations, such as businesses and hotels, and make a viable product with the residue.

CleanO2 has carbon capture units set up at sites across Canada, as well as locations in United States and Japan. Eventually, it plans to set up soap manufacturing at those sites as well, partly to reduce the CO₂ emitted during shipping.

One hotel in Minneapolis uses CleanO2’s technology to scrub the carbon from its furnace, and puts the soap products in its rooms, effectively closing the CO₂ loop.

Canadian Tire, Sobeys and Safeway, as well as Walmart’s Canadian e-commerce site, are among retailers that already carry CleanO2’s soaps. Power companies such as Fortis BC and Atco Ltd. also purchase the products. CleanO2 is just at the start of an expansion that will see it go from shipping 5,000 units to 100,000 units over the next three months.

Now, Mr. Cardiff says he expects the company to be financially self-sustaining in the next two to three months.

HYPERION GLOBAL ENERGY CORP.

OTTAWA

Hyperion Global Energy is creating what it calls the world’s first carbon recycling business, using an energy-efficient process to remove CO₂ from smokestacks in a host of industries and turning it into minerals that can be used in everything from green building materials to pharmaceuticals.

The company’s strategy involves packing all of its gear needed to run the process into shipping containers, and setting them up at mining, energy and manufacturing facilities that emit greenhouse gases. The host producer needs to make no capital expenditures.

Hyperion then aims to supply a US\$44-billion global market for the resulting materials, such as calcium carbonate. In some cases, manufacturers generating the CO₂ will then be able to buy the minerals back to make their products.

“We have an energy-efficient process and life cycle, right from the inputs to the offtake that we create,” said Heather Ward, Hyperion’s co-founder and president. “This is plug-and-play technology, a drop-in unit that does not require new construction at the site.”

The minerals are non-toxic and Hyperion can adjust the purity based on what customers need for their own products, which could be concrete, paper, plastics or fertilizers. The process creates two tonnes of minerals for every tonne of CO₂ processed, and the material can sell for US\$500 to US\$2,200 a tonne, according to Hyperion.

The company’s journey began five years ago, when Ms. Ward teamed up with Jerry Flynn, who developed the technology, which they call the Tandem Carbon Recycling System. Earlier this year, they joined forces with Luke Tucker, a military special operations veteran who is Hyperion’s CEO.

It’s a pivotal year for the company, which operates in Ottawa’s Bayview Yards innovation centre. Hyperion was a semifinalist in the NRG COSIA Carbon XPRIZE, proving with its prototype that it was able to process a tonne of CO₂ a week. Hyperion is now pushing that up to one tonne a day as it builds a pilot system. Later this year, it will work with industrial customers in a path to 20 tonnes a day and beyond.

Meanwhile, it received \$100,000 in seed funding from Crown-owned Sustainable Technology Development Canada, secured close to \$1-million through Ottawa-based Capital Angel Network and won a \$770,000 grant from the Natural Gas Innovation Fund. Hyperion also scored funding from Norway’s Equinor & Techstars Energy Accelerator.

Ms. Ward said the money to develop the technology has allowed Hyperion to hit its stride just as global investment in carbon utilization is reaching a tipping point.

“Once we have our commercial system running at a plant, the world will be our oyster. We’ll have proven the technology at an industrial demonstration,” she said.

CARBON UPCYCLING TECHNOLOGIES

CALGARY

Apoorv Sinha is adamant that cleantech companies must show ability to scale up and commercialize their technology, or the industry will face another burst bubble and frustrated investors.

“A lot of it boils down to, not only execution, but looking at some of the really tough parts around making innovation real, which is talking to customers, making sure that what you are doing actually solves the problem, making sure you are making their lives easier, not tougher, and taking all of that into account when you design your product,” he said.

He believes company he co-founded, Carbon Upcycling, is close to proving itself in that realm with a new memorandum of understanding with a global concrete manufacturer LafargeHolcim to use the startup’s unique carbon-based material in its products.

Carbon Upcycling, a finalist in the Carbon XPRIZE, has nine employees plus contract staff, but Mr. Sinha says that number will increase quickly.

“You compare that to like 70,000 for Holcim, and the reason they’re showing interest is because of the significance this has strategically for them,” Mr. Sinha said at his company’s demonstration facility at the Shepard power plant.

“It’s really a way for us to punch above our weight, and this company is going to have to go to a few hundred employees in the next couple of years if we’re going to make the type of impact that we want.”

Concrete manufacturing is a major source of greenhouse gases, accounting for about 7 per cent of global CO₂ emissions. Hence the industry’s keen interest in seeking breakthrough technology.

Carbon Upcycling’s additive, a supplementary cementitious material, or SCM, can be used to reduce the carbon intensity of concrete, but it can also be an ingredient in plastics, anti-corrosion coatings and a range of consumer products.

The environmental benefit is twofold: First, the company takes the carbon-based fly ash from the generating station and injects CO₂ from the plant stacks into the material in its reactor, which is slightly smaller than a city bus. The additive also makes concrete stronger, and reduces its carbon footprint by 25 per cent.

Carbon Upcycling got its start in 2014, when Emissions Reduction Alberta held a competition for technology to convert emissions into products. Mr. Sinha worked with professors at universities in Calgary, Waterloo and Toronto, who helped prove the company’s prototype reactor could be replicated and scaled up.

Four years later, the company fielded calls from the likes of Burnco and TransAlta Corp. in Canada, and LafargeHolcim, asking if the materials could be used in the construction industry. Its relationship with Lafarge Canada grew as Carbon Upcycling entered the XPRIZE competition. It also joined the multinational building products company’s accelerator program in France.

“The scale-up exercise was because of XPRIZE and their deadlines. But really we could never justify it, quite frankly, for just a science competition. They don’t look at market

traction, they don't look at economics, they just look at scale up," Mr. Sinha said. "What we wanted to make sure was, as a company, we're actually doing something commercial."

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