Oilweek

Grand challenge

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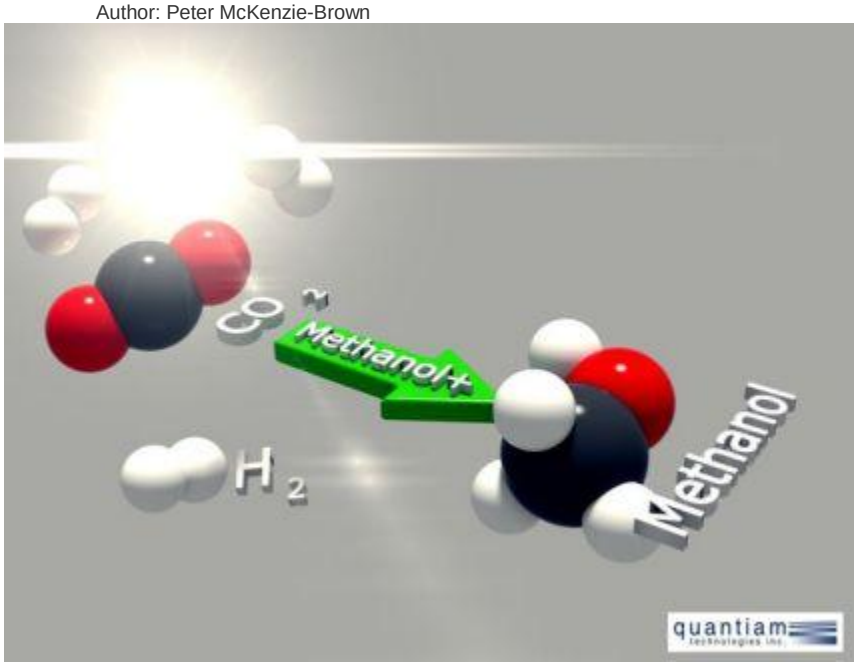

Alberta's Grand Challenge seeks to turn wasteful carbon emissions into a valuable resource

The saying that one person's waste is another's treasure goes back a long way. Alberta's quasi-independent Climate Change and Emissions Management Corporation (CCEMC)—established by the government but funded by imposing a $15-per-tonne charge on the 105 largest emitters for their CO2 emissions—turned it into science. They did so by asking for ways to commercially use CO2 as a resource, then funding a global competition to look for answers.

Managing director Kirk Andries, who has been with CCEMC since the beginning, says the organization is a not-for-profit with a mandate to reduce greenhouse gas (GHG) emissions.

"Alberta isn't the only jurisdiction with this kind of technology fund, but we are the only technology fund supported with these types of regulations," he says.

Emitters have a number of compliance options. They can reduce GHG emissions by continuous improvement; they can buy offsets or emission performance credits from other emitters; they can pay into the fund; or "they can do all of these things; it is up to them to decide how they want to pay the bill."

Such a funding arrangement is possible because the 105 large emitters who contribute to the funding model are responsible for 70 per cent of the province's GHG emissions.

He points out that the largest emitters are not just oilsands operations. As North America's main energy producer, Alberta's unique infrastructure includes, for example, the petrochemical plants at Joffre and Fort Saskatchewan, which are among the major emitters. So are a number of large coal-fired power-generating facilities, for example, the Genesee Generating Station, west of Edmonton.

A "virtual organization" without offices, CCEMC has 90 projects on the books, Andries says.

"We have invested about $230 million in those 90 projects, yet their total value is about $1.6 billion. Our money is leveraged; on average, for every dollar we spend, we get $5–$6 of return. Ours is risk capital, and it is mostly put into projects that would not occur without our funding," he continues. "We support transformative technologies that can deliver meaningful greenhouse gas reductions. In the process, we leverage our money. Sometimes a proponent gets a one-to-one match, but, in most cases, the money supports consortiums of companies that are invested in a particular technology.

"From the GHG perspective, the reduction potential from all the projects we have funded is more than 20 million tonnes by the year 2020," he adds, a number he says is generated at the project level. "When the technology itself is commercialized and then broadly deployed in Alberta and anywhere else, we expect a much greater reduction."

Andries describes GHG emissions as "a global issue, a wicked problem with no solution that we know about," and notes that commercially viable solutions could come from anywhere. "So we needed to have an extensive outreach and marketing program."

There also needed to be an incentive to compete, so the agency offered a $10-million award for the technology that would deliver the best results.

The outcome the agency seeks is a commercially successful technology that could convert CO2 into a useful product, with a net impact of at least one megaton of CO2 reductions. It made sense, he believes, because carbon utilization is an "undeveloped area of science. Most of the technologies that are being worked on are in early stages of development."

CCEMC's Grand Challenge identifies CO2 as a resource rather than waste. "If we could convert CO2 into a real product that has a market that we could create a sustainable business from, then we can reduce the emissions by converting and consuming CO2."

The Grand Challenge took a lot of work to organize, and it began in February 2013. The competition is only partway through, and there won't be another one. "However," he says with a chuckle, "being part of this competition is like being on the TV show Canadian Idol. In the end there will only be one winner, but if you make it into the top 20, you will get a singing contract." He pauses, then continues,"We're running one Grand Challenge only. It will take five years and involve three stages."

The first stage, now completed, was a one-year worldwide competition intended to select 20 winners, though the selection committee ended up choosing 24. There were 344 submissions from 37 countries and every part of the business spectrum. Winning entries received $500,000 each and two years to advance their technology in case they wanted to enter again.

In two years there will be another global competition—the winning competitors from the first round will be evaluated, but with no advantage compared to other proposals at the second intake. The selection committee will choose five winners from this stage and give each winning entry $3 million and two more years to advance their technology.

The last intake will include the five winning entries from stage two. The winner—there will only be one—will receive $10 million to commercialize and establish the business in Alberta. After all, the endgame of this competition is to construct a world-beating business in Alberta.

But, Andries says, "we can't be too Alberta-centric. Alberta has a lot of intellectual capacity in this area, but we do not have all the ideas." That said, he stresses that Alberta has been a leader in this area for many years. "Alberta was the first jurisdiction in North America to put a price on carbon, the first to put a performance target on its large emitters, regulating them to perform."

The province was also one of the first in North America to have a functioning carbon offsets market. "To the best of my knowledge, there are only two that are actually working. One is in California and the other is here in Alberta."

Clearly, the province has demonstrated a lot of leadership on this front. From Andries' perspective, one of the greatest examples of provincial leadership is the CCEMC's Grand Challenge.

And the winners are

What kinds of companies submitted ideas to the Grand Challenge? They were as diverse as carbon science itself.

To appreciate the brainpower that went into the process, consider Quantiam Technologies Inc.—a private company based in Edmonton and a finalist in the first stage of the Climate Change and Emissions Management Corporation's (CCEMC's) competition. The name derives from "quantum-scale innovations," according to chief executive officer and chief technology officer Steve Petrone, but it can mean two things. "Quantum scale is very small, but a quantum leap can be transformational. It picks up on the small scale of matter but also the large scale of achievement."

Now in its 16th year, Quantiam started out as a basic research company with a simple business model. "We sold research services to pay the bills, and that gave us the income to reach our ultimate goal" of becoming an advanced manufacturing company, according to Petrone. He describes his business as "a research and commercialization company. Our drive is to become a manufacturing company with a strong research base. I founded the company in 1998. We now have 32 people, nine of whom have PhDs."

The Quantiam team is seeking what Petrone calls the "holy grail of petrochemicals," producing methanol from captured CO2 emissions and hydrogen. Its process catalyzes CO2 to produce olefins—chemicals with at least one carbon-carbon double bond, which are the carbon molecules used as a building block in the petrochemical business.

"The company is at least half in the clean-tech space, how to reduce emissions and so on," he says, "so the competition really spoke to our personal interests and our strengths." He adds, "We have built one manufacturing facility already, and we soon expect to announce the construction of a second somewhere in North America. The third facility, when we build it, will need to meet the needs of Europe and the Middle East."

Petrone sees methanol as the steppingstone to a hydrogen economy. "It can be directly used for fuel for manufacturing and so on. You do not have to create an entire hydrogen infrastructure. You can roll it out quite easily; it can already be used for fuel."

Equally important is its use as a building block for the olefins that feed the petrochemical industry. Getting into technical mode, he says, "It is the reactivity of that double bond that enables you to take the single molecule and make it into a polymer. You can then make polyethylene, and the polyethylene can be converted into film, Saran wrap, and then into plastics and so on."

He also sees the technology as representing real value to the province. If fully commercialized in Alberta, it would lead to the production of methanol to meet growing global demand and to job creation as industry develops the facilities needed to produce, handle and transport this valuable product. It would also position the province as a key supplier of petrochemical feedstock to world markets.

Although he seems unperturbed by the challenge, he is aware that hydrogen is a relatively expensive product to make. Since one of Quantiam's concerns is the atmosphere's carbon balance, as he commercializes the process, Petrone wants to find green sources of hydrogen for methanol manufacturing.

Initially, he thinks a system using solar power would be viable. "We propose using photo-catalyzed hydrogen made using solar power from the southern parts of Alberta, where there are enough cloud-free days to guarantee that we will not have to take electricity from the grid."

Building a better carbon trap

A professor in the University of Alberta's (U of A's) chemical and materials engineering department, Thomas Etsell led a team in the development of a new kind of fuel cell—a project that caught the eye of the CCEMC, which advanced the U of A project through to the next round of the Grand Challenge.

First developed 175 years ago, fuel cells convert chemical energy from a fuel into electricity—most commonly hydrogen, but more efficient fuel cells use natural gas and methanol, for example. Fuel cells consist of an anode, a cathode and an electrolyte that allow charges to move between the two sides of the fuel cell.

"The easiest way to think of a fuel cell is just as a continuous battery," Etsell explained in an Edmonton Journal interview in July. "But instead of discharging, like your car battery, it keeps on going because you continuously [feed] fuel to one electrode and air at the other one. So you basically burn the fuel by not letting the two come in contact with each other. So the electron transfer that's needed for the combustion is forced through an external circuit—that's where you get the power from."

What makes the U of A's fuel cell different is that it can combine natural gas, CO_2 and air to produce electricity. As a CCEMC summary of the project explains, "Where traditional conversion methods consume energy, this reaction creates it." Other by-products from this process include water and carbon monoxide (CO)—itself an important and profitable commercial chemical.

According to Etsell, "This reaction is very favourable." His fuel cell uses a 50/50 mixture of methane and CO_2. "They basically react to form CO...and hydrogen. The key is we have developed a catalyst that basically favours hydrogen being oxidized rather than CO. When the hydrogen reacts, it forms water.... So the net result is that it produces a mixture of CO and water.

"You get rid of CO_2, you produce power and you produce a valuable by-product in CO," he sums up. Even more than in the case of Petrone's methanol plant, Etsell's idea is uneconomic. A 500-kilowatt fuel cell could eliminate about 5,000 tonnes of CO_2 per year, but it would cost 10 times as much per unit as a comparable gas-powered generating facility. He hopes that mass production will bring costs down but cautions, "They do have some fairly expensive materials in them, so you can only get the cost down so far."