

# Carbon dated

## Officials want Gillette to be the Silicon Valley of carbon

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Jake Hamann works to install rattling bolts and tighten up a structure as he works on the Integrated Test Center at the Dry Fork Station power plant north of Gillette on Friday afternoon.

- News Record Photo/Kelly Wenzel

There's something innately cool about having a front-row seat to watch as science fiction becomes fact.

It may not have the imaginative allure of commercial space flight for the masses, but the nearly two dozen research teams racing to turn one of the world's most environmental concerns into valuable resources has even greater potential to positively affect the planet.

That's what's keeping science geeks like Marcius Extavour nearly giddy as they imagine the potential for capturing waste carbon dioxide emissions from power plants and other industrial processes and turning that CO<sub>2</sub> into marketable products.

Extavour, who holds a Ph.D. in physics, is director of technical operations for the NRG COSIA Carbon XPrize. He said he has been impressed with the imaginative and creative research emerging in a race to turn a waste product into valuable assets.

Science is only touching the surface of the potential, from using the captured CO<sub>2</sub> to make stronger concrete building blocks that could revolutionize the construction industry to breaking it down into other industrial chemicals to extracting the carbon to make nanotubes and even creating a sustainable food source by turning it into edible protein, Extavour said.

"We're at a really fun part of the competition where we're starting to see some of the glimmer of what these teams (are working on),"he said. "There is a range of products (being researched) that are really exciting and different. Some projects may seem less sexy, but they have the potential to soak up a lot of carbon, like the fuels or chemicals or concrete."

Spurring that research is the Carbon XPrize, which has incentivized the research by offering a \$20 million prize pool for teams to develop commercially viable ways to capture and repurpose CO<sub>2</sub> emissions.

Now in Round 2 of the competition, 23 research teams are competing for 10 finalist spots. Five of those will be chosen to complete their research at the new \$21 million Integrated Test Center now under construction at the Dry Fork Station coal-fired power

plant north of Gillette. The other five will get on-site research space at a natural gas-fired plant in Canada.

As construction of the ITC facility rolls into its final stages, Extavour and other officials are excited for the finalists to begin their on-site research in the spring.

For Wyoming and northeast Wyoming, there's more at stake than just being the home to potentially planet-changing breakthroughs.

### **Silicon Valley of carbon**

Wyoming's strongest economic driver is also one of its most vulnerable liabilities. Coal production from the Cowboy State, and the Powder River Basin specifically, accounts for more than 30 percent of the coal burned in power plants across the United States.

It also has paid for billions in new school construction through public land leases. The other fees and taxes it pays the state props up the general fund.

The solution to that dependence on a single industry is simple to define — diversify. Achieving that economic diversity isn't a simple and has eluded decades of economic development efforts, said Phil Christopherson, CEO for Energy Capital Economic Development.

For the first time, large-scale carbon capture research is going to happen at the ITC and Dry Fork Station. Along with the ongoing development of the 5,000-square-foot Advanced Carbon Products Innovation Center near Gillette and the abundant coal deposits around the region, Christopherson said he and other officials are already working to make Gillette the home of future carbon manufacturing that develops from the XPrize research.

"If you look at other places where the XPrize has been, those areas turn into hubs for those types of industry," he said. "The companies doing this research are trying to

commercialize a product. They can do that here. We want to turn Campbell County and Gillette into the Silicon Valley of carbon products.”

After decades of working without much success to diversify the local economy, using the XPrize research to extend to not only reusing the carbon captured in CO2 emissions, but to extract carbon from coal, there’s finally a glimmer for the Powder River Basin to use its coal resource for other industries besides power generation, Christopherson said.

“I believe this is our best chance (to diversify), and it’s a great way to go,” he said. “It takes our existing industry and moves it to the next step.

“If we could mine 300 million tons of coal for the advanced carbon products market in addition to the thermal market, we’d be doing great,” he said.

### **ITC update**

Work building the 225,900-square-foot Integrated Test Center has slowed a bit, but it’s still on schedule to be finished by the end of the year, said Jason Begger, executive director for the Wyoming Infrastructure Authority and Gov. Matt Mead appointee to oversee the ITC project.

The original timetable had the construction finishing in October, but it’s going to take a couple of months longer than that, he said. Most of the delays have been in getting some custom-made equipment for tying the ITC into the power plant’s flue gas system, said Dennis Thorfinnson, ITC project manager for Basin Electric, which owns Dry Fork Station.

“We’re still working on the infrastructure,” he said. “Some of the specified valves we have to have specially made have been on a three-month delay. What can you do? What we’re putting in here isn’t really available at Home Depot.”

He said the estimate now is to have all five of the smaller test bays, which will be used by the XPrize teams, finished by mid-December. A large 108,900-square-foot test bay will be done by mid-January.

Because the XPrize teams won't be going into Round 3 until June, there's plenty of time to make sure the facility is ready, Begger said.

XPrize officials toured the ITC site a couple of weeks ago to see the progress, Extavour said. Not only is the project on pace, he envisions it could be a draw for those interested in science and the CO2 research. Rather than being secretive, he'd like to see people tour the ITC and see firsthand what's being done there.

"We want people to visit this," he said. "You'll see five really amazing technologies. We want the competition to be a showcase for these teams."

He also said it could be a showcase for Dry Fork Station as well. As one of the newest coal-fired plants in the nation, Basin Electric as a company has shown it's passionate about being in on the development of these potential breakthroughs, Extavour said.

"It helps that it's a modern facility and they run such a tight and clean operation," he said. "You can feel the excitement (about the ITC) when we visit. Everyone knows about it and people are generally supportive of it."

As for Christopherson's vision of Campbell County becoming the Silicon Valley of carbon products, that's something Extavour said could happen, because "Gillette is really ahead of the curve."

### **A boost from the DOE**

Although a tenant hasn't been chosen to occupy the large research bay at the Integrated Test Center, there has been some interest from private corporations and groups with some significant financial backing, Begger said.

A recent move by the U.S. Department of Energy has the potential to really spike interest in the ITC's unique facility, the only one in the country that can offer a research team controlled access to large amounts of flue gas.

The DOE has recently announced it will give up to \$100 million in grants for two large coal research projects.

"This grant is tailor-made for what the ITC is looking to do," Begger said, adding that since the announcement, "we're starting to get a lot of interest, and for good reason. ... We've been receiving a lot of calls from different technology developers looking to get our specifications."

One inquiry came from a lab in the Boston area that's working with other companies on carbon capture technology, he said. That group already has about \$25 million invested into its research.

"The timing could work well (for that group), because if they have private financing, they could move pretty quickly," he said.

That means they could move into the ITC right away and begin working while still waiting for word on the DOE grant.

The value of the ITC to Gillette will go far beyond the XPrize competition, Begger said.

"If we can capture some of these first big pilot projects (that grow out of the research), and more than just one, we can create an environment or economsystem for these projects to come to Gillette because of the critical knowhow we're creating here."

While the challenge for research teams at the ITC is to capture and repurpose CO<sub>2</sub> emissions, the challenge for Campbell County and Gillette is to parlay that research into a carbon research and manufacturing hub.

Begger said the best way to accomplish that is to foster a reputation that, like Silicon Valley is for computer technology and manufacturing, there's no better place to produce carbon projects than Gillette, Wyoming.

### ***By the numbers***

\$15 million: The initial buy-in approved by the state Legislature in 2014 for construction of the Integrated Test Center.

\$6 million: Money pledged to augment the ITC construction includes \$5 million from Tri-State Generation and \$1 million from the National Rural Electric Cooperative Association.

225,900: Total square feet of research space, including five 23,400-square-foot test bays and one 108,900-square-foot bay.

\$20 million: The amount of prize money offered in two tracks — natural gas and coal — for the NRG COSIA Carbon XPrize. Each track will pay out \$2.5 million to five finalists, and a final \$7.5 million prize for the overall winner in each track.

### ***The teams***

Between the natural gas and coal-fired power plant tracks for the \$20 million NRG COSIA Carbon XPrize competition, 23 teams are semifinalists in Round 2 of the contest. The goal is to develop a viable method to capture and repurpose carbon dioxide from power plant emissions into the most profitable product.

Finalist that will conduct large-scale research at a gas-fired plant in Canada and a coal-fired plant near Gillette will be chosen later this year.

The 23 semifinalist teams are:

Aljadix

A team from Switzerland that proposes to use captured CO<sub>2</sub> for sea-surface microalgae cultivation to produce a biocrude oil that can be upgraded to renewable diesel fuel. "Renewable diesel is a 100

percent replacement for diesel fuel and can go directly into any diesel engine, with or without blending,” according to the team’s outline at [carbon.xprize.org](http://carbon.xprize.org).

#### Breathe

This team from India proposes to use a catalyst to achieve selective conversion of CO<sub>2</sub> into other products, like methanol.

#### C2CNT

A US-based team, C2CNT proposes to capture CO<sub>2</sub> and transform the carbon dioxide into carbon nanotubes. The process would be low-energy, low-cost while producing a high-value product. Those tubes can then be turned into any number of carbon products.

#### C4X

From China, this team is led by Dr. Wayne Song, who has more than 25 years of industrial and developmental expertise. It isn’t spelled out exactly what Song’s team will do, but he’s considered an authority on developing bio-composite manufacturing systems.

#### Carbicrete

This Canadian team proposes to use a process called carbonation activation, where CO<sub>2</sub> is injected into wet concrete to give it strength. The resulting construction products will meet industry specs, but cost less and will be more durable than conventional concrete. The team says it has a patented technology that can be used at any concrete plant “with virtually no process flow disruption.”

#### Carbon Capture Machine

This team from the United Kingdom proposes to capture CO<sub>2</sub> in an slightly alkaline water solution which is then laced with a brine containing dissolved chemical ions that can be used to produce nearly insoluble carbonate minerals that can be used commercially. The team touts the “simplicity and reliability” of its process.

#### CarbonCure

CarbonCure Technologies is from Canada also proposes to use its process to strengthen concrete building materials. This team says its technology would retrofit existing concrete plants and allow them to sequester waste CO<sub>2</sub> for later use in the manufacturing process.

#### Carbon Upcycling Technologies

Another Canadian team, Carbon Upcycling proposes to capture CO<sub>2</sub> as solid nanoparticles, which can then be used in any number of commercial applications. Those include concrete, plastics, ceramic and epoxy coatings, 3-D printing filament, super lubrication, asphalt and more.



## Catalyst

This US team proposes to use electricity to “rearrange the atoms present in water and carbon dioxide to make ethanol and oxygen,” according to the team’s online description. More specifically, the team claims that if successful, its technology will produce food-grade ethanol, “turning air, water and electricity into drinkable spirits.”

## CERT

Based at the University of Toronto in Canada, this team uses catalysts to convert CO<sub>2</sub> into fuels and feedstock.

## CO<sub>2</sub> Solutions

Another Canadian team, CO<sub>2</sub> Solutions says it has patented technology that allows for the efficient capture of CO<sub>2</sub>. It’s main component is an enzyme that manages the CO<sub>2</sub> while also using a salt water solvent. The result is what the team calls an “industrial lung,” which captures the waste product with low operating costs. The captured CO<sub>2</sub> can be reused or geologically sequestered.

## Dimensional Energy

A U.S. team, Dimensional Energy proposes to repurpose captured CO<sub>2</sub> to make solar fuels, among other products. Those could produce enhanced photoreactors that improve fluid and light delivery.

## EE-AGG

This U.S. team proposes to capture the waste CO<sub>2</sub> emissions in molecules that can then be used in various ways, including being processed into methanol and other high-value products to sequester carbon dioxide in. That includes construction material or plastics or to make cleaner fuels to cut vehicle emissions.

## Hago Energetics

Led by Wilson Hago, this U.S.-based team proposes to use CO<sub>2</sub> to produce renewable energy.

## Ingenuity Lab

The team, based out of the University of Alberta in Edmonton, Canada, wants “to produce a scalable, artificial photosynthetic bioreactor,” according to its XPrize profile. By using the enzymes in plants, the proposal is to convert CO<sub>2</sub> to sugars, which can then be converted to other chemicals.

## Innovator Energy

This U.S. team is constructing a demonstration prototype of its process to capture flue gas CO<sub>2</sub> and turn it into useful molecules. This is done using a “breakthrough” process, according to its XPrize profile.

### Low-Energy-Consumption

This team from the University of Wyoming and led by Dr. Maohong Fan, wants to use a transformational catalyst to capture CO<sub>2</sub>, then convert the waste product into fuels and chemicals. It proposes to do this by using renewable resources through a new looping process.

### Newlight

This team proposes to use a microorganism-based biocatalyst to extract carbon from flue gas and combine it with oxygen from the air to create a solid molecule called AirCarbon. This new molecule is then converted into a pellet that can be used by industry for any number of uses, including extrusion, blown film, cast film, fiber spinning and injection molding.

### Pond Technologies

Working off years of research, this Canadian team will use an enclosed tank with a continuous algae bloom to convert greenhouse gas emissions into algae biomass. That can then be used to feed other biofuels. To handle the amount of CO<sub>2</sub> in flue gas, the team has designed a large LED lighting system to maintain rapid algae growth.

### Protein Power

One of the more unique semifinalists is this U.S. team, which proposes to capture the CO<sub>2</sub> and H<sub>2</sub> from the plant's flue gas and convert them into oils and protein. The goal is to be able to produce consumable protein that can be used as a food source.

### Tandem Technical

The team from Canada is a little vague in its profile, saying only that it wants to transform captured CO<sub>2</sub> into other compounds.

### TerraCOH

This U.S. team proposes to create a geothermal "battery" that would sequester vast quantities of CO<sub>2</sub> in the earth.