

Company Tries to Catch CO2 Before It Touches the Sky

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Drillers burn off the natural gas that surfaces with oil on a farm in North Dakota. Photograph: Spencer Lowell/Bloomberg Markets

Andre Boulet, chief executive officer of Inventys Thermal Technologies Inc. in Burnaby, British Columbia, holds up a 6-inch piece of charcoal, showing how light passes through toothpick-sized air shafts. He says the crevices in this filter offer a cheap way to capture carbon dioxide before it ascends into the atmosphere and haunts future generations.

Boulet, who has spent \$12 million on his seven-year-old company, predicts Inventys's sales may reach hundreds of millions of dollars in five years -- driven in part by North America's natural gas boom, Bloomberg Markets magazine will report in its May issue.

President Barack Obama calls gas a bridge fuel for the U.S. economy. Power plants, factories and refineries are jumping onboard, lured by a 73 percent plunge in U.S. prices from 2005 to March 31. The country generated 28 percent of electricity with gas in 2013, up from 22 percent six years earlier, according to Bloomberg New Energy Finance.

Buoyed by gas, the fossil-fuel industry is trying to bask in a newfound green image.

“America is now the world’s No. 1 natural gas producer, thanks to safe, proven hydraulic fracturing technology -- making clean-burning, domestic natural gas the fuel of choice,” the American Petroleum Institute proclaims.

Even the U.S. Environmental Protection Agency says natural gas has advantages: It releases 50 percent less carbon dioxide in producing electricity than does coal, the major fossil-fuel polluter, the agency says.

Getting Worse

Climate scientists say gas isn’t as clean as it’s made out to be.

“A 50 percent reduction in CO2 doesn’t mean the air is getting better,” says Anna Michalak, a climate researcher in Stanford, California, with the Carnegie Institution for Science. “It means it’s getting worse at a slower rate.”

Compounding the harm, methane, the main component of natural gas, leaks from oil and gas wells. The EPA may be underestimating the amount of this greenhouse gas in the atmosphere by 50 percent, Michalak says.

Entrepreneurs trying to clean up gas encounter a perverse twist. Boulet says that for now, the only way he can fund his research is to sell the CO2 his filter traps to oil companies. They’ll use it to drill for crude that is dirtier -- and more harmful to the environment -- than natural gas.

Oil Sands

Boulet is working with Calgary-based Husky Energy Inc., in which Hong Kong billionaire Li Ka-shing and his companies have a 70 percent stake. He says Husky will trap carbon from its natural-gas-powered boiler that creates steam to extract petroleum from Canada’s oil sands, which the Sierra Club says produce the planet’s most toxic fossil fuel. Boulet says Husky will inject the carbon into an oil field near Lloydminster, a town that straddles Alberta and Saskatchewan, to boost production in a process called enhanced oil recovery, or EOR. Mel Duvall, a Husky spokesman, declined to comment.

John Bennett, the Sierra Club’s executive director in Canada, says such efforts to trap CO2 are misdirected.

“Carbon capture is a myth the oil industry uses to convince us to continue burning fossil fuels,” says Bennett, who adds that governments should back renewables and conservation as higher priorities.

Boulet says he’s willing to work in the oil sands in the short run because the money he makes will enable

him to invest in research with far broader uses: helping gas- and coal-fired power plants and industrial sites respond should governments restrict CO2.

EOR Steppingstone

Starting in 2015, Canada will cut average pollution from new coal-fired plants roughly in half by limiting them to 925 pounds (420 kilograms) of CO2 emissions per megawatt hour.

“EOR is a steppingstone,” Boulet says. “A little bit of evil for the greater good.”

The U.S. has no such restrictions on carbon dioxide, at least not yet. The EPA says CO2 accounts for most greenhouse gas emissions from human activity. In 2009, the agency labeled six gases, including CO2 and methane, as threats to public health because they contribute to global warming.

The U.S. is scheduled to complete its first CO2 rules by January, starting with new coal-fired power plants. The regulations won't affect most new large gas-fired facilities, which with today's technology typically operate at less than their proposed limit of 1,000 pounds of CO2 emissions per megawatt hour.

Obama is also targeting methane. On March 28, his administration said it will propose rules to cut methane emissions at landfills and coal mines. It also ordered the EPA to study methane leaks from oil and gas drilling and could limit those emissions starting in 2016. Separately, the Interior Department will issue rules to curb methane venting from wells on public lands this year.

Ratchet Turns

Four years ago, Obama told United Nations delegates the country would reduce greenhouse gases 17 percent by 2020 from 2005 levels, and 83 percent by 2050; in September, the State Department predicted a 7.5 percent drop by 2020 without additional regulatory measures.

John Thompson, director of the Fossil Transition Project for the Boston-based Clean Air Task Force, says the EPA may require carbon capture on natural gas when the agency updates its mandate in eight years.

“The ratchet only turns one way,” says Thompson, whose group works with businesses and governments to promote low-carbon research in the U.S. and China.

Thompson says the world also needs CO2 restraints on cement factories, steel mills and petrochemical plants. These facilities, which can't run solely on renewables, produce a quarter of global CO2 emissions, he says. In the U.S., about 100 gas-fired industrial sites that have won operating permits since 2012 will

emit as much CO₂ as 20 new coal plants, the Washington-based Environmental Integrity Project [says](#).

“If we don’t capture carbon from natural gas, we can’t get where we need to be on climate fast enough,” Thompson says.

Low-Carbon Future

The U.S. Department of Energy, for its part, is funding research on how to lower the cost and improve the efficiency of capturing CO₂ emissions from both coal and natural gas, says Julio Friedmann, deputy assistant secretary for clean coal.

“These investments, and the technical ability to capture and safely store emissions from natural gas, are an important part of the administration’s efforts to move toward a low-carbon energy future,” Friedmann says.

He declined to comment on whether legal limits on CO₂ emissions from natural gas may be reduced in the future.

Inventys’s Boulet, 40, is part of a small band of entrepreneurs chasing riches by [removing](#) carbon from the so-called clean fossil fuel.

He’s betting hydrocarbon consumers will increasingly opt to trap emissions from natural gas, if not to help the environment then to duck potential government sanctions -- or to sell CO₂ at a profit. He says he can capture CO₂ for \$15 a ton, about one-sixth the cost of technology that relies on ammonia-based chemicals called amines.

No Tourist

“I don’t want to be a tourist in life,” says Boulet, who retired for two years after his wife got rich in the stock market, then returned to start Inventys in 2007. “This isn’t such a daunting task.”

Steven Chu, an Inventys director who was Obama’s energy secretary from 2009 to 2013, says if the invention works outside the lab, it could join a parade of rapid advances in low-carbon technologies in the past five years. Among them are photovoltaic cells whose prices have fallen 80 percent and cheaper automotive batteries. Inventys can do something these technologies can’t: reduce carbon emissions from steel mills and petrochemical plants, says Chu, a Nobel Prize–winning physicist.

“I’m investing the most valuable thing I have -- my time -- to help them get a real shot at success,” he says.

Boulet, who holds a chemical engineering degree from the University of British Columbia, worked with

industrial gases at what was then QuestAir Technologies Inc. in Burnaby. He designed gear to extract hydrogen from natural gas, and, in turn, use hydrogen to power fuel cells for cars.

Activated Charcoal

At Inventys, he began experimenting with so-called activated charcoal, a form of carbon that's treated with oxygen to open tiny pores. He discovered that when CO₂ is exposed to cold air, it forms a weak chemical bond akin to static cling inside the pores. Steam is all that's needed to break the bond.

A prototype in his Burnaby lab outside Vancouver sandwiches 4-foot (1.2-meter) tubes of charcoal between metal discs and stands them straight up. The assembly rotates, and valves open to saturate the charcoal with CO₂-rich gas that in a real-life setting would spew out. Steam washes away the CO₂, which can be shipped to oil fields for EOR.

Boulet says 10 percent of a plant's heat is needed to break the charcoal bond, 20 percentage points less than plants using ammonia-based chemicals. He says his carbon-filter equipment will be small enough to attach to the side of a smokestack.

Some inventors see a future in which natural gas is burned inside sealed systems that prevent carbon from escaping in the first place. They capture CO₂ and pump it into pipelines for distribution to oil fields for EOR or to underground aquifers for long-term sequestration. The U.S. had 4,100 miles (6,600 kilometers) of CO₂ pipelines in 2013.

Space Shuttle

Clean Energy Systems Inc. in Rancho Cordova, California, uses a modified [space shuttle engine](#), which can also burn "synthesis gas," or syngas, extracted from coal, for combustion. The company's roots date to World War II. Founder Rudi Beichel worked on V-2 rockets with Wernher von Braun, the German physicist who emigrated to the U.S. and later helped put men on the moon.

Rocket scientists always understood that sealed, high-pressure combustion needs less fuel and produces fewer emissions than other types, but they didn't see a civilian power market because nobody got penalized for pollution.

"The model we have today is to take carbon out of the ground, use it and throw it into the air," CEO Keith Pronske, 54, says. "In the future, we should put it back," he says, referring to sequestration or EOR.

Pronske's engine looks like a hydra-headed machine with its tangle of natural gas, oxygen and water tubes.

A honeycombed fuel injector lets in enough gas and oxygen for combustion and enough water to prevent melting. Burning produces CO₂ and steam, which spins a turbine to create power. Most plants waste energy in this step.

Pronske says his system is 45 percent efficient, meaning that it converts that much of its fuel to usable power. That equals the efficiency of so-called combined-cycle gas plants, which use gas and steam turbines in tandem, and release CO₂.

Customers can sweeten the deal with Clean Energy's technique by selling CO₂ for \$30 a ton. A 250-megawatt plant would also create 600,000 gallons (2.3 million liters) of potable water a day, enough for 6,000 people, Pronske says.

Abu Dhabi

Clean Energy is finding interest in major gas-producing locales. Maersk Oil, a unit of Copenhagen-based A.P. Moeller-Maersk A/S, agreed in January to investigate the technology with state-owned developer Masdar Abu Dhabi Future Energy Co.

Abu Dhabi is part of the United Arab Emirates, which wants to devote more of the world's second-largest proven gas reserves to its industries. In 2018, a gas-fired plant is scheduled to supply electricity for an aluminum smelter and CO₂ for offshore oil fields.

"We are always under pressure, as we are perceived to be responsible for pollution," says Pieter Kapteijn, a technical director at Maersk, which has a license to market Clean Energy Systems' technology. "This allows us to differentiate our company and use CO₂ for EOR."

NET Power

Bill Brown, CEO of NET Power LLC in Durham, North Carolina, says his technology can generate electricity at a lower price than today's power plants -- and capture CO₂ with no unplanned emissions.

NET Power starts with a sealed, high-pressure system. Oxygen and natural gas are burned to heat up and liquefy CO₂, which drives a device similar to a gas turbine. The CO₂ is recycled back to the combustion chamber. It arrives at 750 degrees Celsius (1,382 degrees Fahrenheit), meaning NET Power needs just 400 degrees Celsius more to hit its optimal operating temperature. The process saves fuel and eliminates a boiler, steam turbine and condenser, says Brown, 58, who has worked at Goldman Sachs Group Inc. and Morgan Stanley, where he was global co-head of listed derivatives.

“We have to replace a lot of power plants that were built after World War II,” says Ralph Eads, vice chairman of Jefferies Group LLC, which holds an equity stake in the startup. “NET Power has a solution that’s economical and environmentally friendly.”

‘Big Market’

NET Power has attracted Toshiba Power Systems Co., one of the world’s largest turbine makers. Hideo Nomoto, the Yokohama, Japan-based research director of Toshiba Power, ranks NET Power’s technology among the top energy innovations of the past 100 years, alongside nuclear power and combined-cycle combustion.

Chicago Bridge & Iron Co. has signed on to build NET Power electricity plants if a demonstration project succeeds; Exelon Corp. will run them. The arrangement melds the creativity of startups with the massive resources needed to fight climate change, Nomoto says.

“We will have a very big market,” he predicts. “It could be any power plant, anywhere in the world.”

NET Power can with no added cost divert CO₂ into a pipeline for EOR or sequestration. The company says it achieves 51 percent efficiency for coal and 59 percent for natural gas. It also says costs, including capital and operating expenses, are \$62.85 per megawatt hour for a NET Power plant burning natural gas. That compares with \$91.63 for a combined-cycle gas plant capturing CO₂. A coal plant trapping carbon costs \$101.25, NET Power says.

Roaring Flares

“We’ve got to be cheaper,” says Brown, who left Wall Street in 2007 to teach at his alma mater Duke University School of Law and start 8 Rivers Capital LLC, which owns NET Power. “We’ve got to be better environmentally,” he says of comparisons to current power plants. “There’s absolutely no doubt this technology can produce tens of billions in revenue within 10 years.”

NET Power is attracting interest in petroleum country. In North Dakota’s Bakken formation, oil drilling exploded so fast that few companies waited for pipelines to haul away natural gas that comes with the crude. Roaring gas flares light up the desolate landscape, emitting amounts of CO₂ equal to two and a half coal plants, according to a Clean Air Task Force analysis. Brenda Jorgenson, who raises cattle atop a valley explored by Meriwether Lewis, says gas fumes turn trees yellow. When a flare sometimes blows out, it fills her home with methane.

Bridge Fuel?

Natural gas can't be the bridge fuel that the industry portrays if too much methane escapes, says Jim Barry, the Dublin-based head of renewable power investing at BlackRock Inc., the world's biggest money manager.

"You see estimates of 1 to 6 percent of gas being released at wellheads," Barry says. "It's been suggested if it's more than 3 percent, natural gas is no better than coal," Barry says, referring to [studies](#) at Cornell University and elsewhere showing that the combination of methane and CO2 amplifies damage from gas. "This must be objectively determined."

North Dakota is investigating whether NET Power can help with an array of energy issues, including flaring. Last year, the state and two power companies that belong to the Lignite Energy Council spent \$1 million to assess the technology for electricity the Bakken needs. Lignite is a low-grade coal North Dakota has in abundance. Initial findings on the plant, which could burn natural gas or syngas from lignite or both, were encouraging, says Al Rudeck, planning vice president for Minnesota Power, a unit of Allete Inc.

'A Breakthrough'

"NET Power is a breakthrough," he says. "It helps us move to less carbon intensity in a responsible way."

John Harju sees another plus. Harju, associate director for research at the Energy and Environmental Research Center in Grand Forks, North Dakota, says such a plant could sell carbon for EOR and help prolong the biggest U.S. oil discovery in four decades.

He says he's confident he can make EOR work in the Bakken's nonporous rock -- and potentially develop a market for billions of tons of CO2 that would otherwise linger in the atmosphere. The oil itself will then be burned and produce more CO2.

North Dakota Governor Jack Dalrymple says in the long-term, CO2 will play a huge role in the Bakken.

"We need to be able to capture the carbon, pump it over to the Bakken oil fields and create economic value with it," Dalrymple says.

If oil produced with EOR replaces Midwestern U.S. crude extracted through traditional drilling, about four-fifths of the CO2 consumed in the process will remain trapped underground, a 2013 [study](#) by the Pembina Institute, a Calgary-based environmental group, found.

Captured CO2 from power plants and elsewhere might also create incentives to build gas pipelines and help reduce flaring, says Brad Crabtree, vice president of the Minneapolis-based Great Plains Institute. Without

a longer life for the Bakken, there's less enthusiasm for such infrastructure. In the short run, North Dakota should force drillers to spend more to combat flaring, Crabtree says.

10 Years

Tim Profeta, who chairs the advisory board for NET Power owner 8 Rivers Capital, says the U.S. natural gas boom can go two ways in the next decade.

“These 10 years will be our enemy if we only think about cheap gas and stop investing in low-carbon technology,” says Profeta, who also directs Duke's Nicholas Institute for Environmental Policy Solutions. “These 10 years will be our friend if we use them wisely.”

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