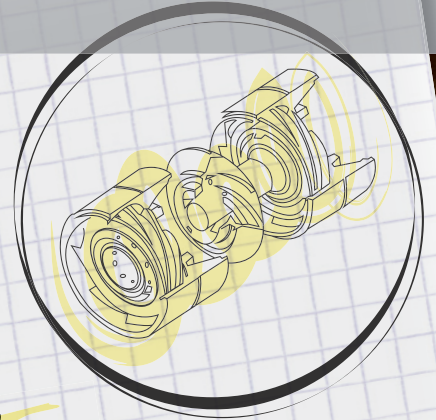
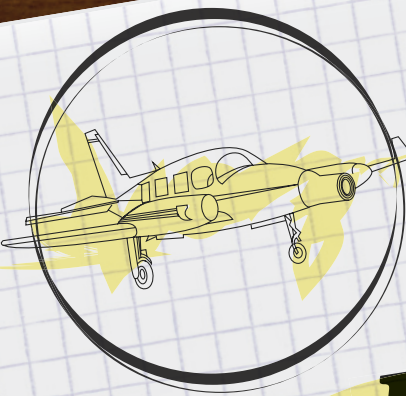


New Technology

NOVEMBER 2014

magazine

THE FIRST WORD ON OILPATCH INNOVATION

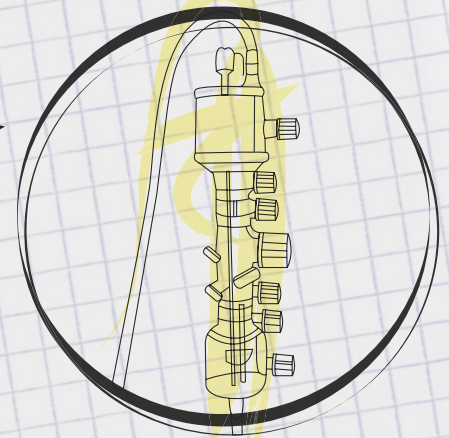


Ingenuity

in the

PATCH

Technological change has transformed the energy sector—**Technology Stars** recognizes those driving the innovation forward



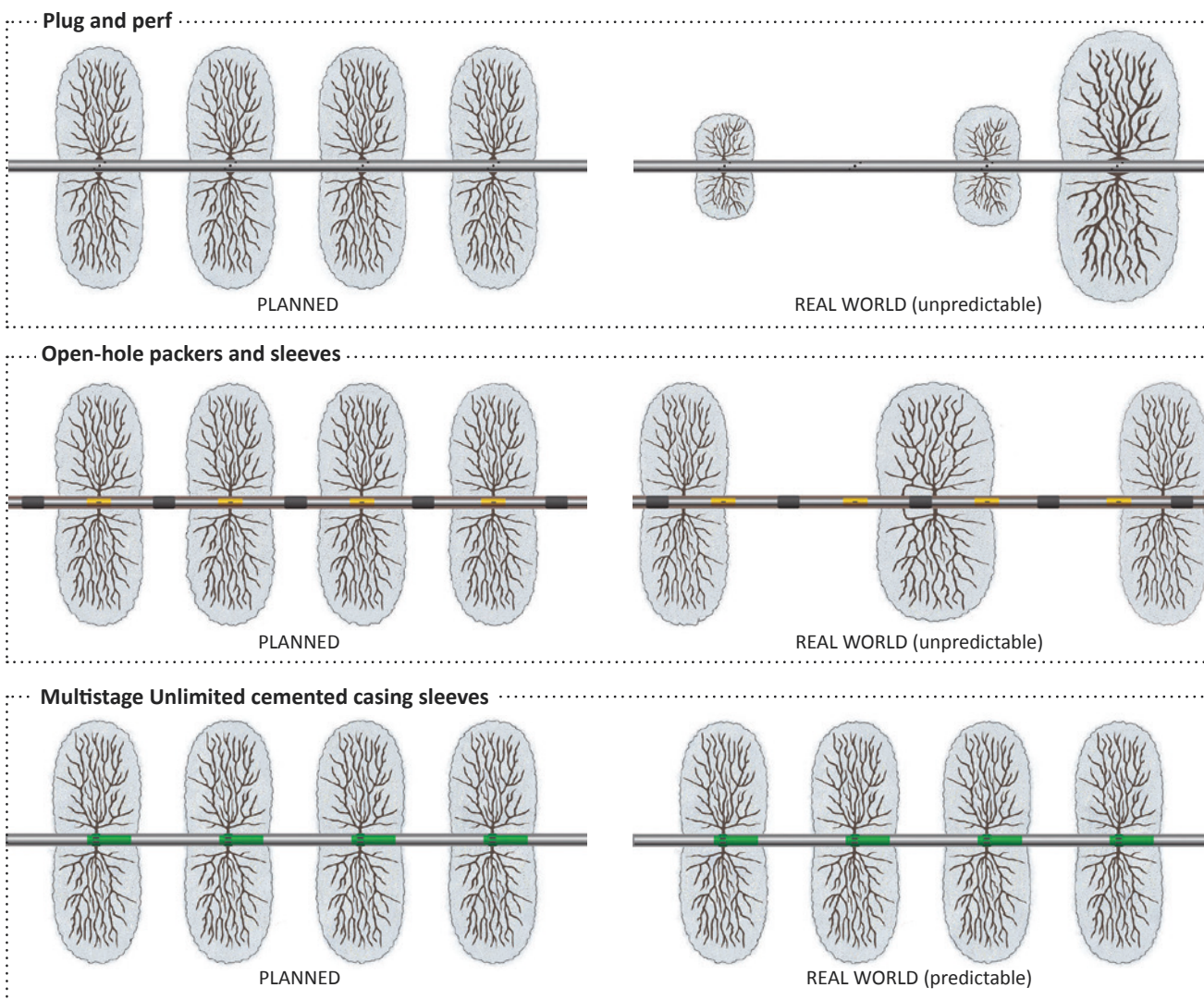
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Crackdown on flaring prompts new solutions to preserve and use associated gas

37 Saying No To H₂O

New fracture process aims to entirely eliminate water use

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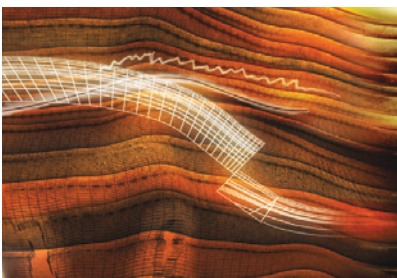
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EDITOR'S VIEW

ONLY GETTING STARTED?

It seems that almost daily we hear about old records being broken as the unconventional oil and gas resource bonanza continues to thrive. U.S. plays like the Bakken in North Dakota and Eagle Ford in Texas are pumping at record rates while the oilsands are setting new standards for both in situ production and overall output. And even as natural gas prices remain low and drilling shifts to oil and wet gas plays, natural gas output from resource plays like the Marcellus in the northeast U.S. continue to surprise on the up side.

But there have been warning signs on the horizon. Unconventional oil and gas resources have unique challenges that go beyond their generally higher costs—and therefore reliance on higher prices.

For the oilsands, the biggest challenge is the environmental one. It impacts both costs, which rise when more attention is focused on environmental impacts, and its access to markets, which is encumbered by the perceived poor record on issues like the accumulation of tailings ponds and growing greenhouse gas emissions.

For shale gas and tight oil production, much of the challenge also relates to environmental issues, as citizens worry about such issues as fresh water use, groundwater contamination, adequate treatment and disposal of produced water, and excessive flaring of associated gas.

Additionally, the fracking boom has been accused of exhibiting the signs of a bubble, both in terms of rapidly declining production curves that require ever more drilling to overcome ever faster declines, and in financial terms as investment in drilling and production has outstripped free cash flow, requiring inflows of capital from borrowing, equity issuance and asset sales.

Fortunately, technology can, and is, increasingly contending with these challenges. While movement may be slow in the oilsands where little incentive exists, in dealing with the mounting greenhouse gas emissions problem, research and development is ongoing—some under the radar, and some potentially game-changing—to reverse that trend. Where more incentive exists, to clean up the tailings ponds and start reclaiming despoiled land, more rapid advancement is occurring and beginning to show tangible results.

Shale gas and tight oil producers are also leveraging technology to reduce the environmental footprint of their operations. Developing the ability to drill several long horizontal wells from a single pad has reduced the area of land disturbance several fold compared to previous practice. Creating environmentally benign frac fluids, increasing recycling of water and switching fuel sources from diesel to natural gas has further reduced the environmental impacts.

But efforts continue, as new technologies are introduced to reduce or even eliminate water use in the multistage fracturing operations that have made unconventional resources commercially viable, and to decrease the level of flaring of associated gas that has become all too common in tight oil plays like the Bakken, which we examine in this issue of *New Technology Magazine*.

Among our Technology Stars in this issue, we also recognize the efforts of those who strive to produce more with less, with tools that range from aerial surveillance of oilsands production, to using shockwaves to “spark” improved production, to adapting old vertical well technology to the new reality of horizontal drilling.

The advances are bearing fruit. While decline rates for tight oil wells remains high, initial production is increasing year-over-year as new technologies and learnings are applied. Also significant, an analysis by Factset for the *Financial Times* published in August indicates that cash earned from operations by 25 leading North American exploration and production companies is expected in aggregate to exceed their capital spending next year for the first time since 2008.

While the switchover from an earlier focus on shale gas to today's dominance of tight oil has helped to improve companies' financial positions, the *Financial Times* also noted an “innovation boom is bringing lower costs and higher productivity.”

It is difficult to say how long the innovation boom will keep companies ahead of the challenges they face. While some predict the shale revolution will subside with a peak in production in the next year or two, others contend we are only getting started, with many more records to be shattered over the next two decades. Based on recent history, it might be wise to bet on technology's side.

■ Maurice Smith

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1st tanker OF WESTERN CANADIAN CRUDE



Suncor Energy Inc. arranged shipping of its first ever tanker of western Canadian heavy crude from Canada's East Coast to Europe in September, Reuters reported. The cargo, delivered by rail to the Quebec port of Sorel-Tracy on the St. Lawrence River, was set to sail to an undisclosed Mediterranean port. The "emergence of this new and largely unnoticed export route" shows that despite environmentalists' efforts to stall new pipelines, producers of the high greenhouse-gas emissions oilsands are seeking other means to get it to markets, Reuters stated.

"THE COMMISSION IS TODAY GIVING THIS ANOTHER PUSH, TO TRY AND ENSURE THAT IN THE FUTURE, THERE WILL BE A METHODOLOGY AND THUS AN INCENTIVE TO CHOOSE LESS-POLLUTING FUELS OVER MORE POLLUTING ONES LIKE, FOR EXAMPLE, OILSANDS."

— *Connie Hedegaard, EU climate commissioner*

In October, the European Union dropped its original plan to label oilsands crude entering the EU market as more polluting than most other oil. A new proposal requires refiners to report an average emissions value of the feedstock they use, rather than singling out oilsands content.

"WE NEED TO GIVE PEOPLE A PLACE TO PROVE, TO DE-RISK TECHNOLOGIES SO WE CAN APPLY THEM BACK IN A COMMERCIAL SPACE. IF WE DO I REALLY THINK THE WORLD WILL EMBRACE THIS."

— *Bob Mitchell, senior director, innovating for performance and sustainability, ConocoPhillips Canada's oilsands business unit*

Alberta needs a flue-gas capture and carbon dioxide commercialization centre—even a campus—where innovators and inventors can toss out their hunches, kickstart innovation and get more value out of the province's hydrocarbons, Mitchell told an *Oilsands Review* Speaker Series talk in September. "I think Alberta has the opportunity, and really, has the responsibility, to be a hydrocarbon utilizer-producer that the world needs. We have a great responsibility, a great opportunity and we just have to think differently about what we're doing and make better use of the natural endowments we've got."



SaskPower commissioned the world's first post-combustion, coal-fired carbon capture and storage project near Estevan in October. SaskPower rebuilt the plant's aging Unit #3, adding carbon capture technology to allow it to cut greenhouse gas emissions by one million tonnes per year. Cenovus Energy Inc. is purchasing the CO₂ for injection into nearby oilfields to enhance oil production. The International Energy Agency called it a "historic milestone along the road to a low-carbon energy future."

"I guess if I were the dictator, I would probably still exploit oil and gas, but I'd do it at a slower rate and try and do more with the oil and gas here, avoiding the problems of shipping."

— *David Schindler, internationally-renowned limnologist*

Speaking to the Under Western Skies: Intersections of Environment, Technologies and Communities conference in Calgary, Schindler said the impacts of oilsands development on freshwater must be a larger industry concern. He also said more Canadian refining of bitumen could generate more income. "This is of course a lot of the reasons why the Chinese and Americans want our oil—they are making more money on it than we are, because they are doing the value-adding."

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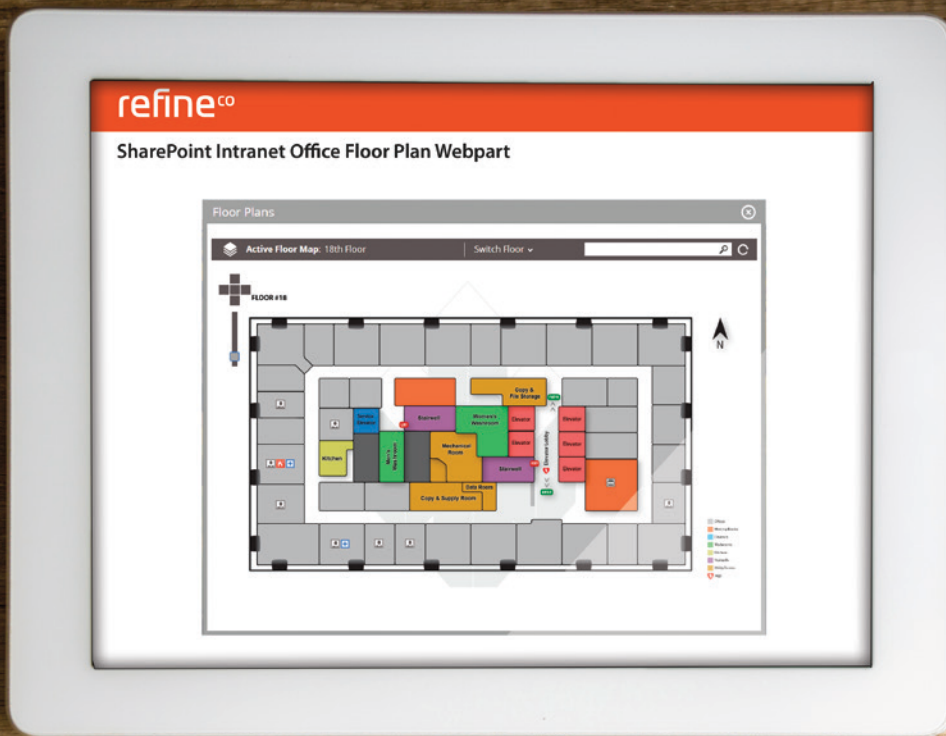
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DATA MANAGEMENT

Bringing User-Friendly To A New Level

Tailored solution allows companies to chart their way through mountains of disparate data

Calgary-based RefineCo Inc. is a high-tech company that uses sophisticated computer software common in the corporate sector to organize documents, staff, petroleum data and other information and packages it in an easily understood format.

If you have a problem getting your head around that, think about how a directory at a large shopping mall can help you pinpoint the store you want to go to.

In fact, some of the same people who were involved in the design of the on-site and online store directory for CrossIron Mills, a 1.4-million-square-foot shopping mall located two kilometres north of Calgary that opened in 2010, have helped RefineCo become one of Canada's fastest growing enterprise content management solution providers.

Eric Veenendaal, RefineCo chief executive officer who founded the company in 2011 with Greg Fleury, partner and chief technology officer, recalls how that came about—and how some of those same mall

directory designers have helped make the company a success.

"I was a consultant, and I was working with a mid-size oil and gas company, now with about \$3.5 billion in revenue and 400 staffers," he says. "They were growing so quickly they were having problems coordinating staffing. They would hire too many engineers and not be able to find where they were seated within the building."

He approached Fleury, and they developed a floor plan feature using similar technology to Google Maps.

That led to RefineCo having an exclusive arrangement with the oil and gas company to develop a set of software-based tools. The floor plan feature required 120 hours to develop, but the client was so impressed that it has worked with RefineCo ever since, and the experience became a launching pad for the company.

Veenendaal and Fleury—who are originally from Winnipeg and Edmonton respectively, where they each previously worked as consultants in the high-tech >

MAPPING SUCCESS

The development of floor plans using technology similar to Google Maps helped launch RefineCo, which now specializes in electronic well file solutions for the oilpatch.

“A lot of these companies have packaged software products and it hasn’t worked. **We develop custom-designed, collaborative solutions.**”

— Eric Veenendaal, chief executive officer, RefineCo Inc.

sector—both moved to Calgary because of the many business opportunities they saw in the oil and gas industry capital.

Veenendaal says RefineCo, which has grown to employ 20 people and now has sales of several million dollars per year (it remains privately held), isn’t reinventing any technological wheels.

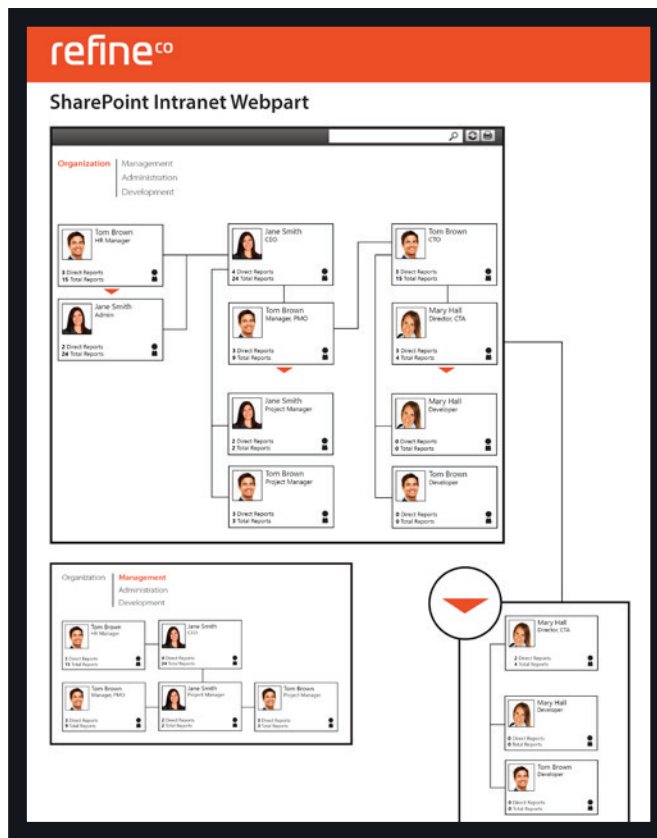
“We’re not married to Microsoft, but the bulk of the software we use is based on Microsoft SharePoint,” which is commonly used in business for document management and staff organization. “It’s a familiar platform, and we’re innovating within that platform,” he says.

The company’s designers take tools like SharePoint and Microsoft’s FAST Search, along with petroleum data management databases, and package them into a simple and familiar format that can be used on multiple devices, ranging from desktops to laptops, tablets and smartphones.

“A lot of these companies have packaged software products, and it hasn’t worked,” he says. “We develop custom-designed, collaborative solutions.”

He says RefineCo develops what he calls accelerators, which are pre-packaged software components that integrate with a company’s existing systems to create solutions that truly fit their needs. Instead of selling them a one-size-fits-all product, they deliver on top of the technology foundations that companies have already invested in.

That information can include organizational charts, documents and records management solutions, strategy, workflow design, searches and, given the industry it largely specializes in, well file



WHO'S WHO

RefineCo can take data, such as that used in organizational charts, and package it in a user-friendly format that can be accessed on multiple devices.

information. All of that is accessible as a cloud-based service.

“We’ve built a product which is like Facebook for well file data,” Veenendaal says. “It requires soft skills and technical skills” to develop the custom-designed packages, he says. “It’s difficult to do because the information keeps piling up.”

It can also develop custom-designed access to some of that data for users not employed by the firms, such as environmental and engineering consultants.

Although much of the software the company uses is Microsoft-based, he says the tech giant’s software is too often “clunky” and not as user-friendly as Apple’s software.

“Our focus is on the user,” he says.

In addition to the ease-of-access it strives to achieve in its products, the company provides staff training as a part of its service, offering webinars, film clips and custom training. It also provides a support desk clients can contact. This consists of a “Meet RefineCo” introduction, as well as instructions on

how to maximize the use of SharePoint and the other software it uses.

While there are competitors who build custom-designed software, Veenendaal says RefineCo can achieve the same results using custom-designed configurations of software that is already widely used within their business. “We refer to ourselves as a hybrid,” he says.

As with many other Alberta-based companies, RefineCo is having difficulty recruiting enough employees to deal with its growth.

“We want people that like technology,” he says. “We like real techie types. Also, everyone who works for us has to have a consultant’s mentality [doing whatever is necessary to satisfy the client].”

It has just wrapped up filming a recruitment video, available on its website, which it will use when it goes to colleges to recruit employees.

“We’re looking at a second location,” he adds, although it hasn’t yet been decided if that will be in Edmonton, Winnipeg, Vancouver or

Ontario, all areas in which the company has clients.

RefineCo has 24 clients now, and Veenendaal expects to double that number in the next couple of years.

However, he says the company “isn’t driven by the goal of moving into a big glass building” but by customer service. The company operates out of a 5,000-square-foot office in downtown Calgary.

Veenendaal says the company has been working on a template that will include software architecture and project management practices that would allow its approach to be more easily repeated. As that product evolves, he says he expects the firm’s growth to accelerate.

RefineCo’s competence has been recognized by those in the technology sector, with it having recently received two awards. In April it announced its debut on the Branham300, which highlights Canada’s top 300 information and communications technology companies.

The company was also awarded silver at the 2014 CDN Channel Elite Awards for the best enterprise solution. Presented by *Computer Dealer News*, the Channel Elite Awards go to solution providers from across Canada in recognition of their innovation, leadership and commitment to business value for customers.

“Channel Elite Awards are the hardest award to win in the high-tech channel,” says Paolo Del Nibletto, editor of *Computer Daily News*. “Companies must show true innovation, while also outperforming the competition. They have to show a lot of heart, dedication and success in delivering creative solutions.”

RefineCo won the award for the development of its Electronic Well File solution, which allows its users to access well records and documents using a single intuitive interface.

“This award validates RefineCo’s commitment of delivering innovative and high value technology solutions through each customer engagement,” says Veenendaal.

In September RefineCo received even more recognition when it was listed as a finalist in the Breakout Business category of the Calgary Chamber’s Small Business Week Awards.

■ *Jim Bentein*

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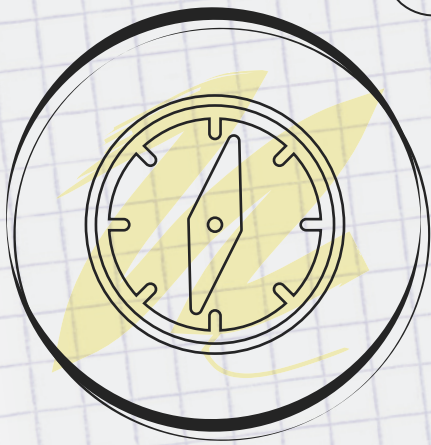
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Ingenuity in the PATCH



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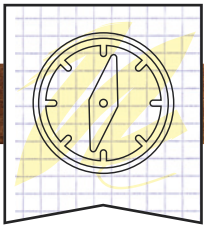
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WINNER: *EXPLORATION*

A NOSE for *Microseeps*

Sky Hunter sensors detect underground hydrocarbons from the air

By Carter Haydu

A proprietary surveying technology that maps microseep data from the sky might seem like an obvious win in the exploration of new oil and gas fields, but it is also a valuable remote sensing tool for monitoring projects already underway in the oilsands, helping companies ensure they do not unintentionally miss any bitumen beneath the ground.

“Our application with regards to SAGD specifically is not for exploration but is actually an operational tool,” says Mark Fawcett, director of business development at Sky Hunter Corporation. Oilsands production using steam assisted gravity drainage (SAGD) entails injecting steam through one horizontal well to produce a steam chamber in the formation and producing the liquefied bitumen through a parallel well.

“Operators often do not know precisely where their steam is actually going, and so when we can do an aerial survey, we can actually show them that perhaps on one well they have extracted everything, but on the well beside it they have missed the pay at the toe, in the middle or at the heel or they have attained nothing at all out of that particular well.

“With repeated time-lapse surveys, this application is able to show where the resource has been depleted.”

According to Fawcett, the ionosphere acts as a giant shield that protects the planet from ultraviolet radiation, and it has a 500,000-volt positive charge potential. In a deep-pressure reservoir, molecular-level hydrocarbon emissions are constantly coming up through the cap rock via microseeps, and anywhere there are sediments such as zeolite, kaolinite and clay a natural cracking process occurs that gives the hydrocarbons a negative charge.

“Once they have that negative charge, the power of the positively-charged ionosphere starts to physically draw, and that is why microseeps are actually pulled out of the ground,” Fawcett says, adding that when Sky Hunter flies its aircraft over an area, the charged collector system actually funnels negatively-charged hydrocarbons into the onboard sensors.

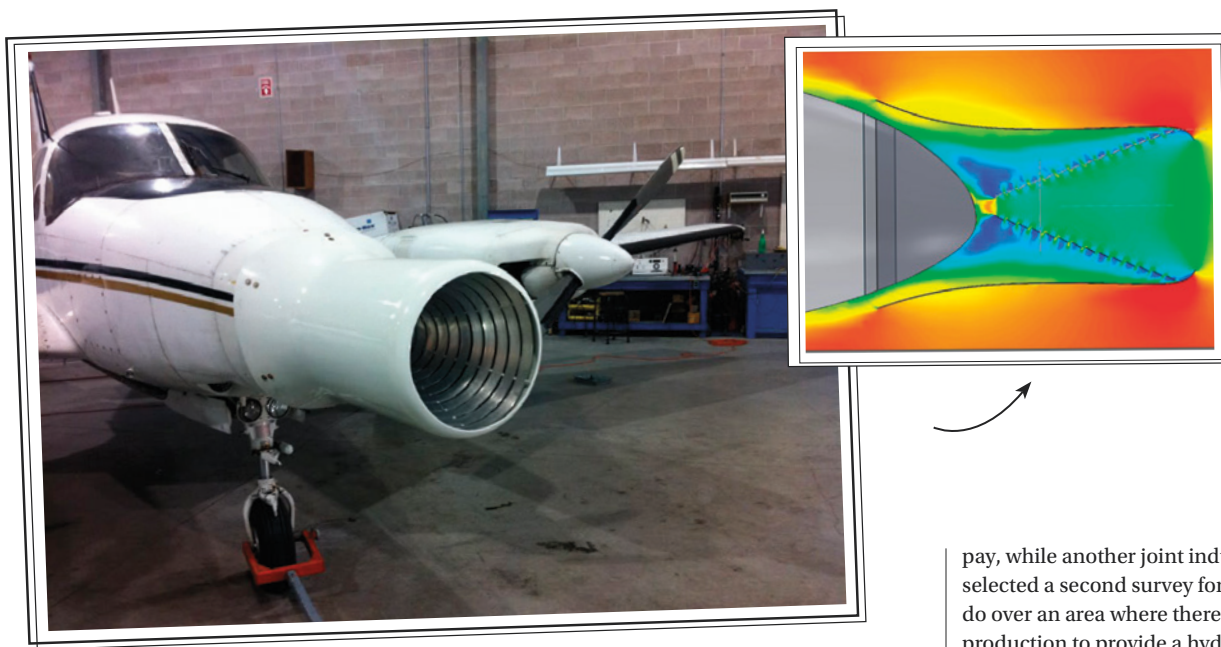
“After a resource has been tapped and the pressure drops, we don’t see the same signal. When there aren’t a lot of hydrocarbons or much pressure in the reservoir, then our microseep signal drops dramatically. It is that pressure in the reservoir that starts the whole process.”

The Calgary-based company’s plane-mounted ion sensors can detect negatively-charged hydrocarbon particles, indicating the existence of oil and gas in a particular area two times out of three. Typically, the plane flies at a constant speed of about 250 kilometres per hour, maintaining a horizontal position to avoid pressure changes during measuring.

“Essentially, Sky Hunter has patented the only technology in the world that can detect microseeps by an aerial survey,” Fawcett says. “We fly a small twin engine aircraft a couple hundred metres above the highest point of the survey, and we can actually map oil, natural gas liquids and methane.”

In a validation project done through Petroleum Technology Alliance Canada (PTAC) and LOOKNorth, Sky Hunter recently partnered with Suncor Energy Inc., Husky Energy Inc., Devon Canada Corporation and Cenovus Energy Inc. to demonstrate the effectiveness of the airborne detection system over SAGD properties.

Soheil Asgarpour, president of PTAC, says his organization helped put together the



HYDROCARBON DETECTION

Sky Hunter's aircraft nose-mounted sensor can detect negatively-charged hydrocarbon particles that have seeped up through the ground, assisting in both exploration and in distinguishing where production has taken place.

consortium that commercialized Sky Hunter's technology, which now serves as a successful example of a small- to medium-sized company able to secure necessary industry funding—a task that is often difficult for similar companies.

"We could bring that idea to the producers, show them the potential benefits and then let them decide if this was a good investment," he says, adding that PTAC maintains neutrality towards the technologies with which it works, letting industry decide what it finds interesting and worthy of financial support.

One survey flown at 50-metre line spacing accurately located SAGD well pairs and bypassed pay, mud channels and spent zones. In total, Sky Hunter conducted four surveys in 2013 through the partnership, leading to additional surveys in 2014.

Fawcett says, "This is the only method that does this sort of survey from an airplane. One of our clients was, in fact, spending several millions of dollars to do 4-D seismic, meaning they would do their seismic again every two years. We can perform a similar function without even putting a foot on the ground, and so the environmental footprint and damage is negligible.

"Our technology actually tells you what is in the ground. It directly detects the hydrocarbons. While seismic data shows you the rocks and layers of the earth, it does not actually tell

you what is in a trap. Traditional geophysical techniques show if there is a good prospect but cannot say if there are actually any hydrocarbons in it."

Asgarpour says that Sky Hunter's microseep detector helps producers understand how a SAGD steam chamber works over time, which is typically quite challenging for industry to measure.

"By understanding growth of the steam chamber, they know if they have a well controlled steam chamber or not. That directly ties to steam consumption and the steam-oil ratio, which determines the profitability and reduction of greenhouse gas emissions of these projects."

During PTAC's 2014 annual general meeting, Sky Hunter received a Leadership in Commercialization award for offering "significant reductions in costs and in environmental footprint as compared to existing methods." Not only does Sky Hunter survey an area in a more economical and ecological way, Fawcett says, but it does so much more quickly as well.

"With our system, we can produce maps within weeks, whereas seismic can sometimes take years to interpret or produce or make decisions based on seismic."

One of Sky Hunter's joint industry partners intends to use the technology every six months over operated SAGD to find missed

pay, while another joint industry partner has selected a second survey for Sky Hunter to do over an area where there has not been any production to provide a hydrocarbon baseline, Fawcett says.

"After their production begins, we can go back perhaps every six months and fly over that area again to show them the difference between the untouched maps and the maps after they have produced, so they can see where they have extracted the hydrocarbon right from the very beginning."

Sky Hunter is also placing additional sensors on its aircraft to monitor environmental anomalies in SAGD properties, Fawcett says.

"It is more to do with changes in vegetation, ground elevation or the management of water bodies. These would be additional sensors not related to the hydrocarbons but rather to the impacts of their production."

The Sky Hunter microseep detector cannot work in rain or during an electric storm, nor can it detect the depth at which hydrocarbons might be found. Survey range is presently limited, Fawcett says, due to the fuel tank size on the relatively small Piper Navajo aircraft.

Sky Hunter is seeking to partner with companies using larger Beechcraft King Air twin-turboprop, which would allow the technology to survey up to 500 kilometres away from an airstrip.

"The next step is to miniaturize our system, completely automate it and put it onto an unmanned aerial vehicle, which could fly for 24 hours unmanned," Fawcett says. "Then we could go thousands of kilometres from the nearest airstrip, and that would be truly remote, frontier-type exploration." ■

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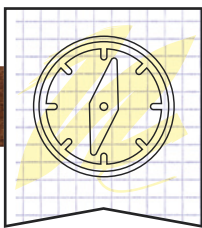
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CAPTURING *Uncertainty*

Exploration software quantifies geologic risk

By Carter Haydu

For the first time, reservoir modelling workflow software exists that not only creates a geological model while conducting seismic interpretation, but also captures reservoir uncertainty throughout the process.

"When you can represent the structures better, then you can make a more predictive model; when you have a more predictive model, then that can tell you where to drill, how to optimize production and so forth," says Garrett Leahy, technical project manager at Roxar AS, a business unit of Emerson Process Management.

"The value we typically give our customers is that they usually enjoy higher recovery rates."

Late last year, Roxar released Model Driven Interpretation (MDI), the latest version of its reservoir modelling software that helps companies make bid valuation, field development and operational decisions through geologic modelling while simultaneously conducting interpretation and capturing geologic uncertainty.

"We can use that horizon to simulate different realizations, and that lets you risk your decision making process," Leahy says, noting that MDI actually interprets a probability distribution of where to find marked lithological changes.

For example, with standard interpretation workflow a company can only guess if it will enter the next formation in 10 metres while drilling. With MDI, though, analysis could determine if there is a 70 per cent chance of entering a formation within the next 10

metres, leading to better decision making and improved investment returns.

"That uncertainty carries down the whole workflow through reserves calculations, fluid predictions and all sorts of different things," Leahy says, adding that interpretation of uncertainties is an industry first.

"We're bringing constraints from the geology into the interpretation process. It basically gives you a much more streamlined, faster workflow."

According to Leahy, MDI brings two fields together—modelling and interpretation—through many complex algorithms conducting complex calculations, which speeds up the interpretation process by a factor of at least two. This means a traditional workflow of six months could be complete in three months or fewer.

"Our strength is in geologic modelling," Leahy says. "We figured out a way to use that strength for interpretation."

Roxar software allows geoscientists to guide and update geologically-consistent 3-D structural models directly from seismic data, allowing clients to focus on where models need more detail, as well as on challenging and complex geometries common in reservoirs.

Developers worked on the MDI program for just over two years. Since its December 2013 release, Leahy says, the reception has been positive, albeit adoption has been slow due to the cautious nature of decision makers within the energy sector.

"The oil industry is very conservative, and we expect it can be slow to make changes, but

we have a couple of very successful case studies where it has been used by international oil companies and down to smaller companies as well. For the first year of a release, we think that we are doing quite well."

Leahy notes that MDI is in its initial generation, and he expects to see continued innovations in the software, improving its functionality and providing clients with even more capabilities.

"We have an algorithm that helps condition the models to seismic data. It does a very, very good job and beats conventional technology hands down. However, we have not tried to solve that same problem for fault data. That is one of the things I would like to see us do within the next year or two."

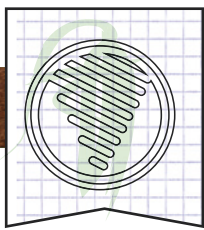
According to Leahy, while horizons are typically represented by contrast in the earth, faults tend to be very difficult to image in seismic data, and finding them comes through noticing discontinuity in horizons—looking at the shadows of something rather than the actual object. This makes it much harder for an algorithm to determine where the fault is, making it more complex computationally.

"There is technology on the market that can do this, but we think we can do it better. However, we are not yet at that commercial stage." ■

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WINNER: DRILLING

AHEAD *of the* curve

Fracking technology leader transforms the drilling process

By Maurice Smith

When a company sets out to change an industry standard, even one that will save millions, it doesn't always find a receptive audience.

When Packers Plus Energy Services, a pioneer of the multistage fracturing technology that helped launch the shale gas revolution, saw an opportunity to improve the drilling and completions process in a way that would cut costs up to 30 per cent, it found just such an audience.

But the company, which Dan Themig, president and chief executive officer, describes as "well ahead of the curve," is predisposed to envisioning technology that the industry, more often than not, doesn't yet know it needs. And so it was with its StackFRAC (SF) Cementor stage collar, an enabling technology that allows drillers to shift from the tried-and-true use of intermediate casing and liners to monobore well construction.

"One of the things Packers has been really good at is, we are a good visionary company. We don't just look at what the competition is doing and go and duplicate that. Our business model has been to try to figure out where we

think the industry would really want to be two or three years from now. It's a difficult place to be because quite often, when you are doing that, you are going to be doing things that nobody has ever done before, that a lot of people say aren't possible, and that a lot of people in the industry would never let you try it on their well because they have never seen anything like it before."

In the past, drillers would start a well with a large hole, run surface casing, drill a smaller hole to the target formation, run intermediate casing, and then run a liner down to the horizontal section of the well—a multi-step, and therefore more costly, process. "It's generally a good process and the industry had adopted it all across Canada," Themig says. But he felt it could be done better.

"What drives our industry are a couple of things; one is higher production and higher recovery, but the other thing is efficiencies in drilling and in well construction and in fracturing stimulation," he says.

Cemented-back monobore well construction, in which the vertical and build sections of the well are cemented from the heel back to the surface with a stage tool rather than running intermediate casing, was seen as a way to cut well construction costs and eliminate the extra trips needed to remove the running string and install the fracture string.

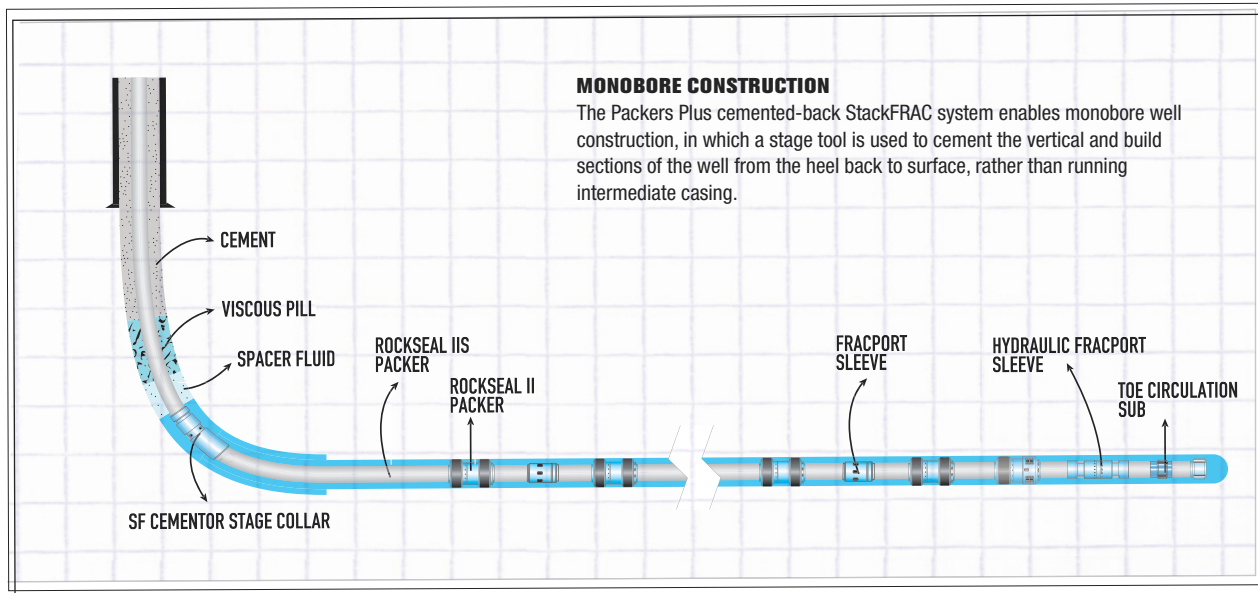
Facing some resistance even within the company, Themig pressed ahead, launching the project that would lead to the SF Cementor. "Looking two or three years ahead, we could see that the industry would want to

convert to monobore well construction, but the problem was that there was no technology that really would allow us to do it at the time. There were cementing stage tools, but they just weren't designed for hydraulic fracturing, high pressure applications, for massive temperature cool downs and those kinds of things—they really were designed for a different place and time, where conditions really weren't very challenging."

Packers set out to try stage tools offered by companies large and small, and wasn't impressed with the results. "The failure rate on cementing stage tools from any supplier was about 10 per cent—so very high risk, and very, very poor reliability. So we decided we needed to develop a stage tool that really changed the game and allowed a seamless implementation of monobore technologies."

There were three main problems with the existing stage tools, Themig says: "First, their sealing mechanisms were not very reliable. Second, once you ran them, they were designed so they had pieces that you had to drill out, and when you did that it left a lot of debris in the well. Historically, nobody cared about the debris, because in vertical wells it would just fall to the bottom of the well. But in horizontal wells, things hang around, so this debris that was drilled up would then interfere with some fairly complex operations downhole.

"And the third was, if you did have a problem, there was no backup plan—basically if your stage tool failed, the well would sometimes be lost, or at least it would be marginalized."



SOURCE: PACKERS PLUS ENERGY SERVICES

To some degree, Themig encountered resistance from within in designing a new tool. “Some of the technical people in Packers Plus did not want to be in the stage tool business. They said, ‘we are not experts, other companies are good at that,’ but I looked at the failure rate and I could see we couldn’t use other companies’ [tools] because they are not going to work.”

So Packers Plus developed a “totally different methodology,” Themig says. “We got rid of wiper plugs, we got rid of baffles that needed to be drilled out—and to my knowledge there had never been a stage tool built that didn’t require a plug to close the sleeve. Instead of closing the sleeve with a pumped down plug, we would close it by manipulating the casing, and we incorporated a secondary closing sleeve so if we had a problem, there was a built-in redundancy in the tool, and to the best of my knowledge that had never happened in our industry either.”

The SF Cementor is hydraulically activated and mechanically closed with compression of the tubular. It is accompanied by a debris sub, which accepts a standard Packers Plus actuation ball, to provide a barrier to cement stringers or debris during cementing and to serve as a platform for cleanup operations.

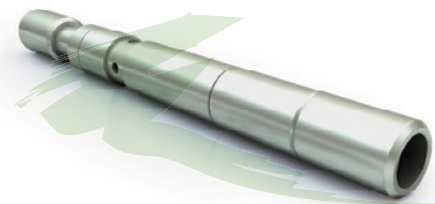
Initially, Packers Plus ran into industry resistance. When the SF Cementor was sent to Packers Plus service districts in both Red Deer, Alberta, and then to Midland, Texas, it sat unused for about six months, Themig says. Resistance likely resulted from the fact the company wasn’t recognized as one that provided cementing equipment to create monobore well construction, he says, and “that what we were doing looks so different from anything they had ever seen before, I think it scared a lot of people.”

But once someone broke the ice and its benefits began to become apparent, and Packers Plus built up a record of successes, the SF Cementor technology began to take hold. “At first the industry still wasn’t converting to monobore construction—it really took probably two more years before the conversion really took place. But once it took place, if you went to our districts now, almost 70 per cent of the wells that we complete now are monobore construction.”

In a recently published case study with Lightstream Resources Ltd. running open-hole, cemented-back monobore horizontal wells in the Cardium formation of central Alberta, Packers Plus reports the operator completed more than 220 wells using the SF Cementor with 100 per cent success. In a comparison between monobore wells and those with intermediate casing in the East Pembina and Garrington fields, using extensive field data from more than 360 wells, overall drilling cost savings using monobore construction added up to \$177,000 per well in the East Pembina, an 11 per cent savings, and \$483,000 per well in the deeper Garrington, a 20 per cent savings.

The tool has been run in more than 35 formations, including the Montney, Cardium, Bakken, Marcellus and Eagle Ford, reporting savings as high as 30 per cent in some cases.

The system’s success is such that Packers Plus has now surpassed those companies that have been manufacturing stage tools for decades to become the biggest supplier of stage cementing equipment in western Canada. It has patented the technology and is now launching it worldwide. Packers Plus has run jobs in the Middle East and Indonesia and is rolling it out in Argentina and other regions this fall.



ENABLING TECHNOLOGY

A hydraulically opened, mechanically closed stage cementing tool, the SF Cementor stage collar is used to cement the vertical and build section above open-hole StackFRAC systems in monobore wells.

“I think we are going to see an adoption of this Canadian technology worldwide, and this will be one of the higher impact trends,” Themig says. “I think the reason it has been so impactful is the cost savings. On a total well construction basis, with roughly 20 per cent savings, you cut \$1 million off a \$5 million well.”

The technology-intensive company recently built advanced manufacturing facilities in Edmonton and Houston and now owns over 60 “families of patents based on innovative technology that mostly originated here in Canada,” says Themig, adding, “Our percentage of scientists and engineers compared to other companies in our field is nearly double. We have three core values, innovation, operational excellence and customer intimacy, and it all drives us toward innovation; it is really quite a unique culture we have in our company.” ■

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TECHNOLOGY

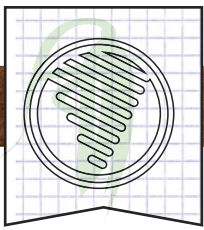
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Diamond impregnated bit designed to drill toughest formations farther, faster

By Elsie Ross

As operators continue to push the boundaries of technology in their efforts to unlock oil and natural gas resources within harder and harder formations, they are turning to fixed-cutter diamond impregnated drill bits to make that possible.

Although polycrystalline diamond compact (PDC) bits have continued to improve over the years—and are now capable of being used in many of the formations that were once the domain of impregnated bits—standard PDC bits simply can't take the shear forces imposed by drilling extremely hard formations, according to Brad Dunbar, product manager for Halliburton's new TurboForce diamond impregnated drill bits, which recently launched in Canada.

PDC bits work by effectively taking big "scoops" out of the rock. In contrast, "you take [an impregnated bit] and turn it at a very high speed and it just wears away the formation [like a high-speed sander]," Dunbar says.

"Impregnated bits are used mainly in very, very hard and abrasive rock, which means it's expensive to bring the bit out of the hole for replacement," he says. As a result, the impregnated bit is desirable in any application where PDCs will wear out and have to be replaced during the drilling operation.

In ultra-tight formations, the extended-gauge bits drill long intervals faster and achieve higher rates of penetration in interbedded formations while generating a smoother borehole that improves logging data collection and facilitates completion design installation.

In northeastern British Columbia, Halliburton's TurboForce diamond impregnated drill bits have been used in the Mattson Formation in the Liard field, where they encountered hard and abrasive sandstone with dolomite and chert stingers. They have also been deployed in the Artex member and Halfway Formation in the Alteres, Town and Caribou fields (hard and abrasive sandstone with dolomite and anhydrite stingers).

The TurboForce drill bits range in size from 3⅞ inches to 17½ inches in diameter. The working portions of impregnated bits are comprised of a matrix containing embedded diamonds, hence the term "diamond impregnated." During drilling, individual diamonds in a bit are exposed at different rates so that sharp, fresh diamonds are continuously being exposed and placed into service.

Dunbar says Halliburton has been working on the proprietary TurboForce package for the last year or two, testing various improvements to its previous package, the IQ Series bits.

One of the advances in the new series is in blade height, he says. The taller blades are made out of a diamond and tungsten carbide mix, and as the bit deteriorates, it just wears down the blade until there is no blade left. "The higher blade allows us to use more diamond so it can stay in the hole longer."

Because the materials in each diamond impregnated bit are very hard and tend to become brittle, the designers have tied the blades together with hydrodynamic bridges. "In this TurboForce design, we changed the bridge design to resemble a hydrodynamic wing. The whole point was to channel fluid across the bottom of the hole [to keep it cool]," says Dunbar.

As the bit spins at an extremely high rate, it is going to heat up; if it gets too hot, without pressure it will change back to the graphite from which it originated. The new bridge design boosts cleaning and cooling, improving performance even in high revolutions per minute (RPM) applications.

Another improvement is the proprietary mass distribution calculation and balancing method in the TurboForce bits, which are designed to negate the underbalanced centrifugal forces and increase the stability of the bit, resulting in longer runs. >

“Because all the tiny chips of diamonds are randomly placed, there is no way to [balance the forces acting on a bit] because there is no way of knowing which diamonds are going to engage at what time,” he says.

“So instead of trying to force balance it, we tried to mass balance it, using a statistic as to how the mass of the diamond is across the bit so we can achieve greater stability,” says Dunbar. “It’s turning at such a high RPM that if mass is in both directions it could actually tear apart.”

A new active gauge geometry also increases stability and reduces differential sticking, in turn reducing the chance of a stuck bit. “The gauge pads are not a cutting element; they are just there to keep the bit in the centre of the wellbore,” he says. The design aims to put as little torque generation as possible on the gauge pad to increase stability.

Additionally, the TurboForce continuous shoulder profile provides an increased contact area that also improves stability, while the higher diamond content extends the life of the drill bit, resulting in longer runs.

Developers designed a proprietary wear indicator which clearly shows the degree of wear



HARD ROCK CUTTER

Containing a number of new innovations, Halliburton’s TurboForce diamond impregnated drill bits provide higher rates of penetration in interbedded formations.

from zero (new) to eight (worn), which provides onsite engineers with valuable insight related to selecting bits for future runs, says Dunbar.

In test runs using products designed for specific geographic areas, the TurboForce bits are consistently delivering long single-run performance, according to Halliburton. For example, in the Bromide Formation in Oklahoma, an 8½-inch TF510D bit drilled 119 metres, achieving 2.13 metres per hour on turbine at 1,170 RPM and was pulled with even wear.

In the Republic of the Congo in July, an 8½-inch TF616B bit set new performance benchmarks for both footage and rate of penetration (ROP) through a difficult conglomerate in another test run. The bit drilled 245 metres at an average ROP of four metres per hour compared to competitor bits drilling 88 metres at 3.3 metres per hour and 205 metres at 2.6 metres per hour respectively. ■

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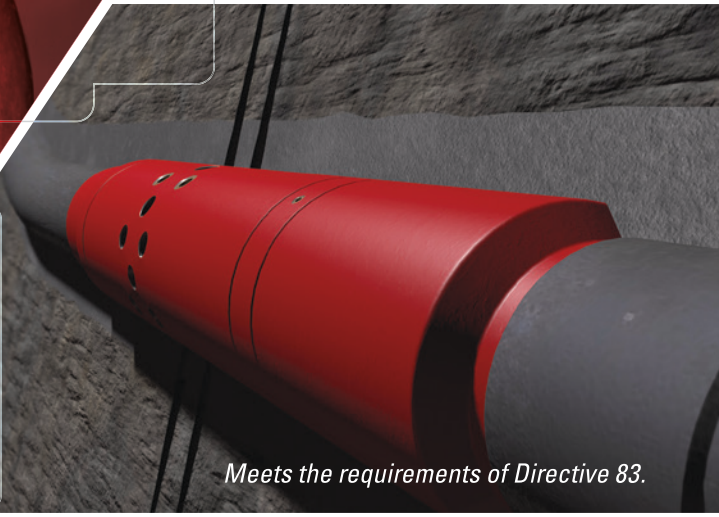
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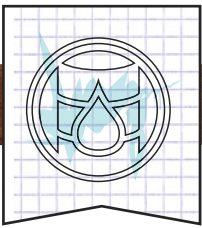


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WINNER: *PRODUCTION*

Waves OF INNOVATION

Having solved the unconventional oil and gas puzzle, focus turns to optimizing production

By Maurice Smith

The upheaval in oil and gas production brought on by horizontal drilling and multistage fracturing has led to great advances in optimizing those technologies. Now, companies are increasingly turning their attention to optimizing production of unconventional wells, which have been characterized by extremely high early decline rates.

Baker Hughes has combined its expertise in various aspects of field development to meet that need with new technology that breaks new ground in areas as diverse as pumping, remote monitoring and software. A suite of offerings under the ProductionWave banner, it has quickly become one of the fastest growing production solutions in the company's history.

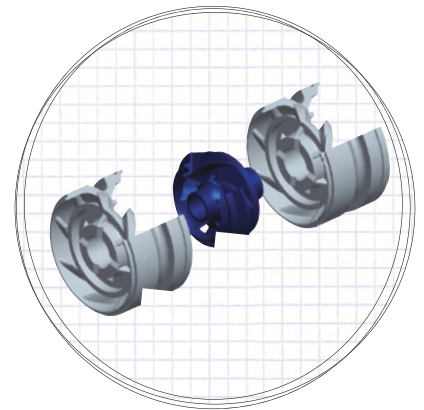
"In the unconventional, the industry has become very efficient on the drilling side and in how they complete wells [fracturing], but we are still on a fairly rapid learning curve in producing those wells. Now, the focus is starting to shift to production," says Kathy Shirley, Baker Hughes director of marketing for artificial lift.

"There are thousands of unconventional wells out there and customers are starting to look at the longer term, looking at their production phase to determine the best approach to optimize production, and I think that's going to continue."

Horizontal wells—which, along with hydraulic fracturing, cracked the code for production from shale and tight formations—are typically 5,000 feet deep and stretch another 5,000-10,000 feet laterally through the formation. In oil producers, volumes start high but trail off rapidly, often from thousands of barrels per day down to under 100 per day in their first year. That creates a range of volumes conventional pumping technology could not manage with any single pump. Light tight oil is also frequently accompanied by associated gas, creating multiple fluid phases that cause problems for traditional pumping technology, such as gas blocking, gas locking and gas slugs.

It was to solve such challenges that Baker Hughes developed the new downhole architecture, first launched in September 2013. Its ProductionWave solution, with the FLEXPump electrical submersible pump (ESP) at its heart, consists of a suite of technologies which can be custom tailored on a well-by-well basis in what the company calls a service value multiplier. In three "waves" of product launch, the company initially tackled the flow variation problem, then gas mitigation, and then tight radius wells.

Typically, producers have solved the first issue by using an ESP or other higher-flow lift method when production is high,



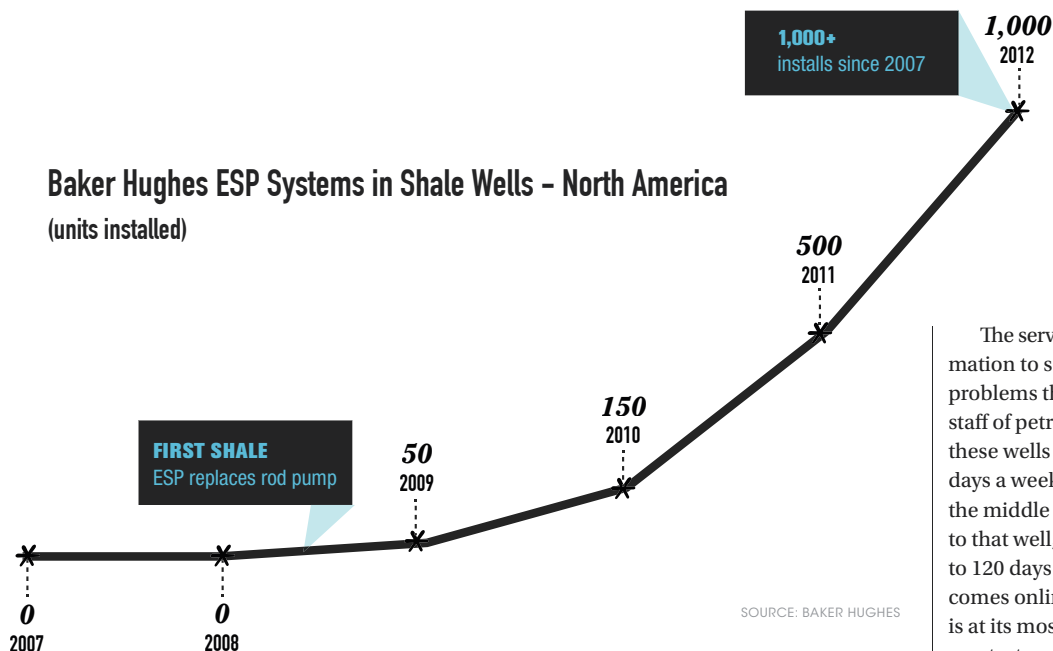
and switching to a rod lift pump when it declines, because higher-flow systems had not been designed to also accommodate low flows. But rod lift pumps, which use the reciprocating motion of a downhole pump assembly activated by a large—up to 47 feet tall—surface pump jack, are poorly suited to unconventional wells. Rods impact the tubing wall, for instance, and excessive gas can lead to gas locking.

"What was so critical about our FLEXPump series of ESP pumps was that, for the first time in the industry, an ESP was capable of getting down to 50 barrels a day [pumping capability], which has traditionally not been possible," says Shirley.

Not only is the FLEXPump more effective and reliable than rod lift pumps, but its use avoids the need, and cost, of switching out to a lower rate pump. FLEXPump systems can accommodate flows from 2,900-50 barrels per day, a range that covers most unconventional wells through their lifetime. "With the steep decline

Baker Hughes ESP Systems in Shale Wells - North America

(units installed)



UNCONVENTIONAL SUCCESS

Catching the updraft in booming unconventional oil production in recent years, ProductionWave has become one of the most rapidly adopted production technologies in Baker Hughes' history.

The services include both a degree of automation to solve many of the most common problems that arise as well as access to "a staff of petroleum engineers that are manning these wells remotely 24 hours a day, seven days a week, so they can catch something in the middle of the night and make adjustments to that well," Reid says. "During that first 90 to 120 days when an unconventional well comes online is when the production stream is at its most volatile, and when you have the greatest opportunity for issues to arise for the downhole equipment. So I think that is really going to bring a lot of value."

The company's ability to leverage all its product lines also extended to its chemicals products, Shirley says. "Baker Hughes is one of the few companies that can integrate the artificial lift and upstream chemical worlds. We have people who are looking at both and understand how the chemicals interact with the metallurgy of the artificial lift systems, and understand the fluid properties to design the most effective chemical treatments. We are launching some new technologies in the chemical space this fall, including a downhole H₂S scavenger."

A relatively new offering for ProductionWave is to offer a greater level of ongoing involvement in production operations as well as more financial flexibility in making it available to customers.

ProductionWave "opened a completely new market for us to be in, and that changed a lot of what we normally do," says Reid. "We are more involved in the customer economics and in understanding the reservoir. We have an ESP engineering group specifically assigned to understanding the unconventional."

Baker Hughes offers ProductionWave for sale, for lease or lease-to-own to better match producers' operational expenditure with their production where necessary, he says.

Of the ProductionWave's initial success, Craighead said sales "have surpassed expectations, with more than 1,000 installations year to date across every North American oil basin, from Alaska to the Eagle Ford. ProductionWave has been one of the most rapidly adopted production technologies in the history of our company and is becoming a meaningful driver of our North American growth story." ■

curves from the unconventional wells, that was really the critical tipping point for what made ProductionWave possible," Shirley says.

"From an environmental standpoint ESP systems are much more sustainable. There is a very small surface footprint, the potential for leaks and that sort of thing are minimized versus a huge rod pump on the surface, and even in not having to change out systems, you are minimizing the impact that comes with having to pull equipment and bring in a workover rig," she notes.

The second wave incorporated the latest gas mitigation technologies, making the ProductionWave solution applicable where free gas at the intake is up to 99 per cent, or 100 per cent when combined with the company's MaxRate software.

Baker Hughes' Electrospeed Advantage variable speed drive (VSD) uses MaxRate software to sense a drop in torque on the ESP system, which indicates a gas lock or slugging occurrence, says Paul Reid, director of product development at Baker Hughes. "There are algorithms that go into it which can actually handle the event, rather than shut your system down and require a field service intervention or whatnot. So it allows us to ride through the gas lock and recover from it without shutting the system down."

In the event of a gas occurrence, the software can reset the VSD to slow the pump rate, stopping flow to the surface and allowing back flow through the pump to flush gas accumulations from behind the impeller vanes. When cleared, the VSD will ramp the speed back up to begin pumping.

The company's Gas Avoider pump intake also plays a role in dealing with associated free gas. During system operation, the intake's

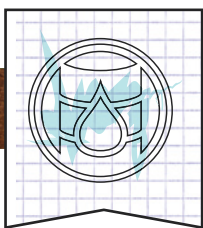
gravity cups swivel to close off upper entry ports, allowing gas to migrate past the intake while the lower gravity cups open to allow entry of higher amounts of fluid. It keeps gas from entering the pump, regardless of the ESP system's orientation in the well.

And its MVP multiphase pump, the most efficient gas handling pump in the industry, features a unique split-vane impeller design that reduces the tendency for underload shutdowns due to gas interference, while its GM Performance Series rotary or vortex gas separators work to separate free gas from the production fluid.

The third wave announced last summer included the FLEXlift Curve, which Martin Craighead, Baker Hughes chairman and chief executive officer, called "the world's first artificial lift system engineered to be deployed below the ever-tightening bend angles which are common in unconventional, and then set in the horizontal section at the maximum depth and extension possible."

In a conference call in July, Craighead said that is important because the deeper you can set the pump, the higher the drawdown rate, resulting in higher production rates. "Until the unconventional took off and we began drilling 15,000 horizontal shale oil wells per year in the United States alone, there was never a need to design a system that can navigate around a tight bend radius and operate horizontally, and no one ever has until now."

New monitoring technology is tying it all together. Part of the company's monitoring platform, the ORBIS asset decision solutions is expanding its offering to address the production challenges typical of newly completed unconventional wells with ORBIS PLUS 24/7 surveillance services.



Spark of INGENUITY

Stimulation pulsing clears near-wellbore damage, bolsters production

By Jacqueline Louie

Blue Spark Energy Inc.'s Wireline Applied Stimulation Pulsing (WASP) tool is all about improving connectivity between the near-wellbore and the reservoir.

The tool is a patented technology that uses small amounts of energy over a very short time frame to create a shockwave and pressure pulse that in oilfield applications can be targeted to remove near-wellbore damage. According to Blue Spark, it's like a spark plug in a car, delivering thousands of pulses in one trip into the wellbore. WASP generates pressures of up to 10,000 pounds per square inch (psi), as well as an intense shockwave.

"It's a viable, cost effective alternative stimulation for near-wellbore damage," says Dan Skibinski, Blue Spark business development director, explaining that with WASP's electro-hydraulic pulse, Blue Spark has harnessed the ability to use a high-pressure pulse in an oilfield application, in a manner that's safe and functional for controlled use in a wellbore. "It fills a niche in the stimulation world between perforating and hydraulic fracturing. There isn't another technology like this."

Blue Spark compares how the technology works to a lightning bolt. "When lightning strikes, it super heats the air. WASP creates the same effect, using approximately a kilojoule of energy to create intense heat," says Mike Perri, Blue Spark geosciences data manager. "Every five seconds, each pressure pulse is generated from several hundred megawatts of power in a few microseconds. That's the equivalent of a gigawatt of energy for one microsecond—enough power to run the city of Calgary for one microsecond."

In the oilfield, WASP directs its high-pressure pulse toward the reservoir in order to remediate near wellbore damage, which is typically caused by scale formation,

completion damage and organic fouling—all which reduce formation connectivity.

The technology can be used on any well that has sustained damage during part of its lifecycle, whether during the drilling, completion or production phase, on both producing and injection wells. Alternatively, it can be used to remove precipitate buildup in completion equipment, such as in tubulars, valves and mandrels.

WASP can also remediate completion equipment such as sand screens, liners and gravel pack applications where plugging is causing a reduction in connectivity.

According to Blue Spark, WASP provides a technique to either re-establish near wellbore connectivity, or to improve access to the reservoir for larger remediation techniques.

Perri notes that the pulse emitted from a WASP treatment extends only to the near wellbore region—up to one metre—and for a typical well, a WASP treatment takes four to five hours to complete.

WASP, which requires some fluid in the hole in order to propagate the pulse, can use existing wellbore fluids that are non-compressible. It can be deployed as a standalone remediation solution or, while not a direct replacement for remediation technologies such as hydraulic fracturing, acidizing and perforating, it can complement those stimulation techniques.

"Although we can't perforate the steel casing, the method typically used to complete a well, we can make perforations, acid jobs and hydraulic fracturing more efficient and effective," Skibinski says.

Typically, only 20-40 per cent of the perforations in a well are completely open, which can be attributed to glazing, compaction and debris from the perforating charge, or a combination of all three. "The WASP technology can remediate those perforation tunnels to create more effective perforations."

Adds Perri: "If you run us before an acid job, we help make new pathways so the acid can more effectively be used to treat the formation."

Additionally, WASP can be used to stimulate the formation without having to isolate the zone.

A private oil and gas services firm headquartered in Calgary, with operations in the U.S. and France, Blue Spark Energy introduced its WASP technology to the market nearly three years ago. On average, wells using the technology have increased oil production by more than 120 per cent over a 90-day period, the company says. WASP has seen an 80 per cent success rate on the 200-plus wells that Blue Spark has completed treatment on globally, both onshore and offshore, in the Middle East, North Sea, U.S., Eastern Europe and Canada.

WASP is an alternative technology that is "safe and environmentally friendly, because we don't use explosives or chemicals," Perri says. "We don't pump anything downhole. And we have a small footprint on a lease, with just two pieces of equipment, a third-party wireline truck and our pickup."

In terms of the technology's limitations, "we can't make every well better. Only wells with near wellbore damage can be improved by WASP," he adds.

WASP can operate at temperatures of up to 120 degrees Celsius and 10,000 psi (69 megapascal).

"It's really an opportunity to change the way you look at remediating a well," Skibinski says. "It's more effective. It does things that other techniques can't do. It fills a unique niche in the oil and gas industry." ■

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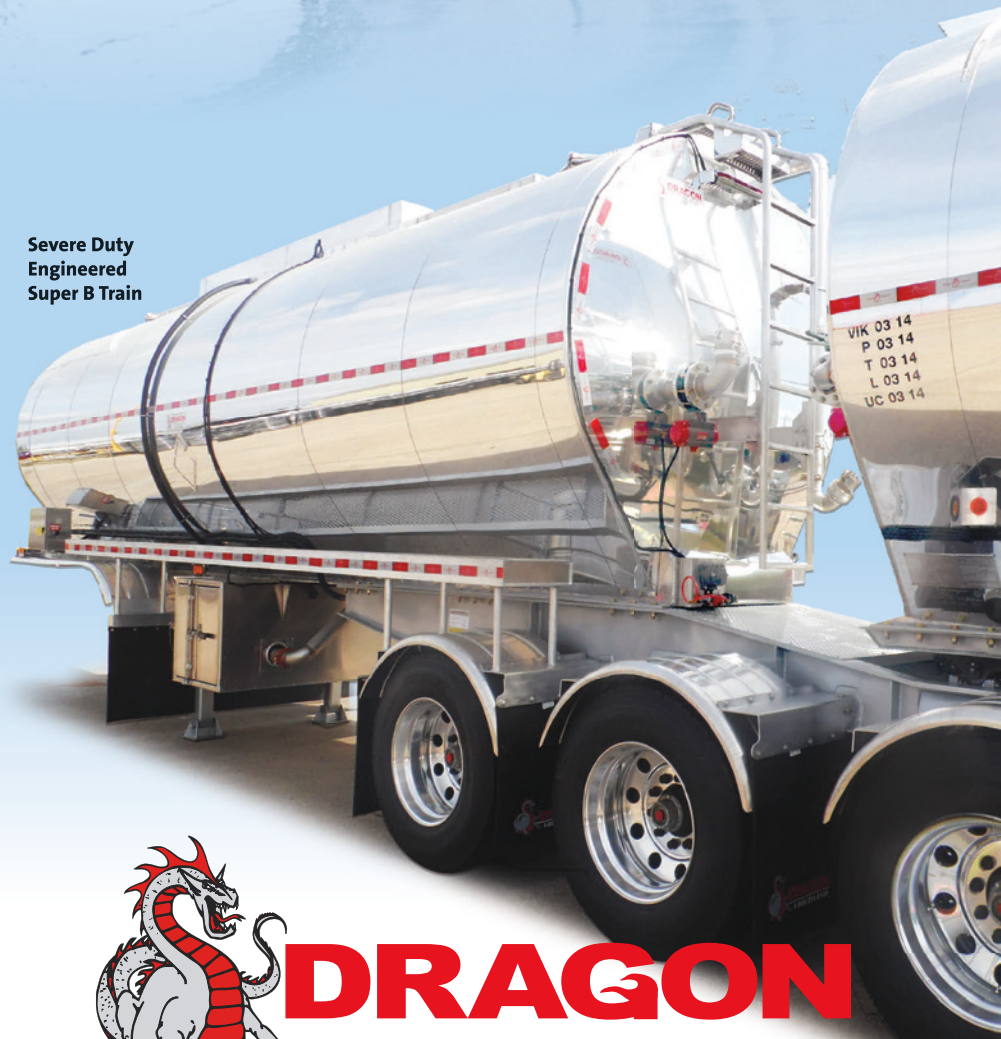
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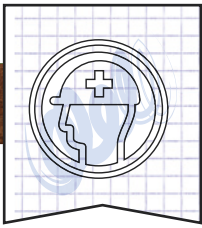
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OILWEEK



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Nature Shows **THE WAY**

Advanced disinfectant technology developer sets sights on oil and gas applications

By Jim Bentein

A small publicly-listed Santa Ana, Calif.-based company that is developing water purification and advanced disinfectant technologies, all using some form of iodine, sees one of its Edmonton-developed technologies as a way to clean up and even eliminate oilsands mining tailings ponds.

"With our technology you can reduce the footprint of and even eliminate tailings ponds," says Dennis Calvert, president and chief executive officer of BioLargo Inc., which is listed on the NASDAQ bulletin board in the United States.

Despite its small size, the company has secured 12 U.S. patents for its iodine-based technologies and has another eight pending for what Calvert calls multi-billion dollar business opportunities.

And while that might sound like hype, the company's water purification and disinfectant technology developed by Edmonton-based inventor Kenneth R. Code, from whom BioLargo purchased the rights to the iodine-dosing system concept in 2007 (he remains its chief science officer), is expected to be piloted at an oilsands mining site in the next year or so.

The road to commercial application of its Advanced Oxidation System (AOS) Filter technology to treat water in oilsands tailings and in other water treatment applications is well advanced. The company is a founding member of a research chair launched about

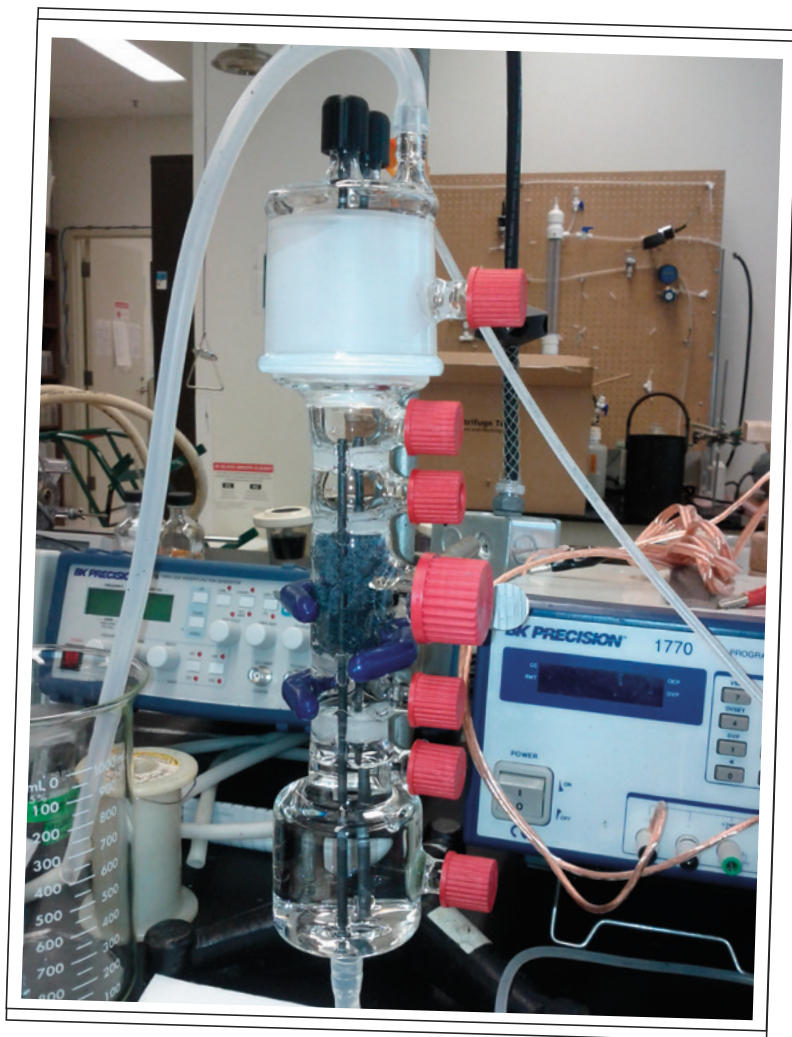
three years ago at the University of Alberta (U of A) focused on evaluating technologies to help solve contaminated water issues in the oilsands.

That chair, sponsored by the Natural Sciences and Engineering Research Council of Canada, includes membership by such oilsands industry giants as Syncrude Canada Ltd., Suncor Energy Ltd., Royal Dutch Shell plc and Canadian Natural Resources Limited, along with Alberta Innovates and Environment Canada. Calvert says laboratory tests of the AOS Filter at the U of A led to significant validation of the technology in preparation for the tailings pond field pilot test.

The company is also exploring many other opportunities for deploying its technology. "The most rapid adoption is likely to be in the area of [treating and disinfecting] industrial produced water," he says. "Tailings ponds will happen more slowly because of the scale."

The most likely areas where the company's iodine-based technologies will be adopted are in the food processing and refining sectors, he says.

"We believe our technology is world-class," says Calvert. He adds that the BioLargo technology will eventually be deployed in developing nations, where the quality of drinking water is an urgent health issue. "It could also end up under the kitchen sink," where the effectiveness of existing water filtration systems could be accelerated using the company's technology.



ADVANCED OXIDATION SYSTEM

Originally developed in Edmonton, BioLargo's water purification and disinfectant technology is being tested for a number of applications, including agricultural water treatment and oilsands tailings ponds cleanup.

distribution licence deal for its Isan precision iodine dosing system with Clarion Water, a new operating division of InsulTech Manufacturing LLC, which has more than 20 years of commercial success worldwide in the water disinfection sector.

Based on the use of iodine, which Calvert calls "a powerful, broad-spectrum biocide," the Isan disinfection system is seen as "the logical replacement for chlorine in applications involving irrigation supply and post-harvest sanitation," he says. It delivers iodine with exact precision for fortification, or depending on the application, it can take it back out.

It will initially concentrate on the agricultural sector. Clarion has already marketed the Isan system in Australia and New Zealand and will now market it worldwide. Under the licence agreement, BioLargo received a \$100,000 payment upfront and will earn a royalty on sales for the next two years.

MAGIC OF IODINE

Iodine is common to all the applications BioLargo is involved in. The chemical element, the heaviest essential element used widely in biological functions, has long been known as the broadest spectrum, most powerful disinfectant known. Even NASA recognizes iodine's unique qualities, the company notes, using it as the only water disinfection process on all manned space flights.

"All of the work that we have done over the years is to advance our technology for the use of iodine across a number of different market segments," says Calvert.

The AOS Filter technology, a new invention that has been developed by the company in the last three years, deploys the power of iodine and electrolysis using a kind of steady shower technology that decontaminates and removes odours at one-twentieth the cost of existing approaches, Calvert says. In addition, there is little power consumption when the technology is deployed.

"We're enhancing the performance of widely understood technologies," says Calvert. "In testing we validated that our AOS Filter was able to dismantle and remove [contaminants] in seconds versus hours [with other technologies]."

He further explains how the technology works. "What we have done is we have taken an oxidizer, iodine, and we have combined it with well-understood technologies like >

But for now the company is continuing to work with U of A researchers to prove up its approach in treating tailings water. It is also working with Lynn McMullen, U of A professor in the department of Agriculture, Food and Nutritional Science, who is researching the use of the AOS Filter in food processing, livestock and other agricultural sectors.

However, as a small company with limited financial flexibility (it has raised \$15 million in private equity), the company is concentrating on strategic partnerships and on the speedy adoption of its technology in a variety of industries.

NUMEROUS APPLICATIONS

"We think of ourselves as a platform technology company," Calvert says. "We have a number of initiatives that are starting to generate revenue. We're focused on selling the licence [for the technology] to established companies."

To speed up adoption and generate revenue, the company is working with other

firms involved in the pet care sector, since its technology can be used for odour abatement, and in the medical sector, where iodine-based solutions are used for advanced wound care.

Last year it announced it had sold a version of its technology called Suction Canister Solidifiers to the U.S. Army Medical Agency, where the product will be used in triage and surgery during troop deployment. It had previously sold a version of the technology that solidifies bodily fluids and eliminates odours to a medical facility at Langley Air Force Base.

That product design was developed by its Clyra Technology division, which has developed super absorbent pads and wound dressings, woven and non-woven wound dressings and other medical products, all of which have earned or are awaiting U.S. patents. Although no dollar figures were announced related to the arrangement, the product could now be deployed by all U.S. military forces, representing a significant market, Calvert says.

In mid-August the company announced it had entered into a manufacturing and

“What it means basically is we have taken a filter, and we have converted it into a reactor, so we can then operate at very high flow rates and at incredibly low levels of energy. So the device features high rates of oxidation, low power consumption, high speed and continuous flow.”

— Dennis Calvert, president and chief executive officer, BioLargo Inc.

carbon, filter media, ceramics or membrane technologies, and when we combine those components, we can extract contaminants from the water flow. What is unique about the invention is that we have combined traditional filter media with an oxidizing technology and electricity, which then allows the device to provide an oxidation potential across the surface area of the filter media at an incredibly effective rate.

“What it means basically is we have taken a filter, and we have converted it into a reactor, so we can then operate at very high flow rates and at incredibly low levels of energy. So the device features high rates of oxidation, low power consumption, high speed and continuous flow.”

OIL AND GAS FIX

In the oilsands sector, contaminants such as naphthenic acid and bacteria must be dealt with in water treatment. In addition, there are such hard-to-treat contaminants as acids, ammonias, solvents and dioxane.

Many of the same contaminants are common in other oil and gas processes, such as hydraulic fracturing. BioLargo’s technology could be used to treat recycled water in many areas of the oil and gas industry.

At the U of A, the tests were conducted on contaminated water taken from oilsands tailings, “and the work has proven our effectiveness of dismantling and removing targeted naphthenic acids,” he says.

It now costs an estimated \$2.50–\$3 per barrel to treat contaminated water in the

oilsands mining sector, according to Calvert. “We can do it for a fraction of the cost.”

BioLargo’s suite of technologies has attracted some respected executives to the company. Harry DeLonge, now a senior adviser at the company, was formerly a vice-president of manufacturing technologies with beverage and snack food giant Pepsi-Cola International. Vikram Rao, another senior adviser, spent 30 years with oilfield service giant Halliburton Company, most recently serving as its senior vice-president, senior strategy adviser and chief technology officer.

Tanya Rhodes, a former vice-president of innovation and wound management with pharmaceutical industry giant Smith & Nephew Wound Management, is a senior adviser with BioLargo’s Clyra Medical division.

Calvert says the company’s motto is “To make life better,” reflecting the importance of clean water to humanity. “We think it’s our right to have clean drinking water, but the investment is so high [to achieve that goal] that it isn’t feasible. But we bring an economically viable technology to the table at a fraction of the cost of other approaches.”

Kris Cudmore, who heads Grande Prairie, Alta.-based water logistics company White Water Management Ltd., is so impressed with BioLargo’s technology he wants to get in touch with the company to try it out in the oil and gas production areas where his company works, in northwestern Alberta and northeastern British Columbia.

“We’ve been looking at iodine-based electrolysis technology,” says Cudmore, president

of the five-year-old company. “We’re trying to figure out what the best technology is. I’d like to reach out to them.”

White Water, which supplies water for hydraulic fracturing and other oil and gas uses and also works on water issues in the forestry sector, regularly assesses different approaches to water treatment and recycling. Cudmore says iodine-based treatments make sense. “It [will] be a multi-million dollar technology,” if it works as promoted, he says.

He’s hopeful the technology will reduce the salinity in treated water, which is a major issue. But after having investigated various approaches to treating water, he says he is impressed with BioLargo’s approach.

Water use will only grow as an issue in northern Alberta and northern British Columbia, Cudmore says, and BioLargo’s technology has a huge potential market in the oil and gas industry and other sectors if it works “as it appears,” he says.

His company, which sets up large water storage tanks and pumps water from as far as 24 kilometres away for fracking jobs and treats grey water from Alberta municipalities such as Fox Creek, Rocky Mountain House and Edson for use in fracking, would definitely use BioLargo’s approach if it is as effective as the company suggests. ■

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NECESSITY BREEDS *Innovation*

Crackdown on flaring prompts new solutions to preserve and use associated gas

BY DIANE L.M. COOK

NORTH DAKOTA'S NEW FLARING REGULATIONS have oil producers looking for new technologies to reduce the amount of gas they flare.

According to North Dakota's Energy & Environmental Research Center, as of March 2013, 29 per cent of the over one billion cubic feet per day of associated gas produced in the state is flared. All parties, including the government, the oil producers and the landowners have a desire to see all associated gas captured.

Ever since North Dakota gave oil producers a drilling tax break in 2007, they've been frantically drilling wells. As of July, the North Dakota Industrial Commission (NDIC), the state's energy regulator, reported that there were 11,287 producing wells that produced 1.1 million barrels of oil per day. Produced in association with that oil, at the wellhead as a by-product of oil production, was 1.3 billion cubic feet of gas per day.

The NDIC says the reason why so much gas is flared is that, "Total gas plant capacity in North Dakota exceeds total gas production in the state although many bottlenecks exist in the current gas gathering infrastructure due to the high liquid content of the gas, the prolific volumes of oil and gas during initial production, increasing pipeline pressure that requires installation of additional compressors and in some cases undersized pipe."

To reduce the amount of harmful emissions emitted into the atmosphere

from flaring this produced gas, the NDIC introduced new flaring regulations on March 3. Under the new plan, producers began submitting gas capture plans with all new drilling permits on June 1. On July 1, an order was signed setting capture targets and possible well restrictions.

Effective Oct. 1, producers must capture 74 per cent of their produced gas. The capture rate continues to increase over the next six years with a 77 per cent capture rate by Jan. 1, 2015; an 85 per cent capture rate by Jan. 1, 2016; and a 90 per cent capture rate by Oct. 1, 2020, with potential for a 95 per cent capture rate as the NDIC's ultimate goal.

Based on the NDIC's July production results, oil producers have already met the commission's first capture percentage. The NDIC reported that, "In July, the percentage of gas flared dropped to 26 per cent."

Companies that fail to meet their specified gas capture targets will face penalties, including mandatory production curtailments. But specific wells, or even entire fields of wells, can exceed gas flaring goals as long as the producer is compliant on a countrywide or statewide basis.

For oil producers to continue to meet the NDIC's first capture rate, and its increasing capture rates over the next six years, they need to apply new flaring reduction technologies to their production operations. Two new technologies, one offered by GE Ventures, GE's venture investing group, and partner Ferus Natural Gas Fuels, and the other by LPP Combustion, LLC, are seeking to meet that challenge.

GE Ventures is providing a full-service natural gas fuelling solution for oil producers called Last Mile Fueling Solution, combining GE's CNG In A Box compressed natural gas fuelling technology with Ferus' operational and logistics expertise.

Named for the "last mile," that is, the final distance produced, compressed gas must be delivered from the point of supply to the point of use in remote locations, the technology is part of an end-to-end solution that is comprised of a set of technologies plus a service.

Sanjay Bishnoi, managing director and head of Oil & Gas Investments at GE Ventures, says "The Last Mile Fueling Solution takes produced gas, removes the impurities, compresses the gas with GE's CNG In A Box proprietary technology, and then loads the compressed gas onto Ferus' transport tankers which is then transported to a drilling location to be consumed as fuel, displacing diesel."

Not only does the Last Mile technology help oil producers meet or exceed new flaring reduction regulations, and thereby reduces the



PHOTO: STATOIL ASA

amount of harmful emissions emitted into the atmosphere, but the technology also allows oil producers to generate a new revenue stream by separating out the valuable liquids from the produced gas and selling those liquids to third parties. The technology also lowers oil producers' costs of transporting diesel fuel to site for their drilling operations.

Bishnoi says GE has its Last Mile technology employed with several oil producers in the Bakken and that the company is looking to expand beyond the Bakken into other basins in North America. As well, Bishnoi says GE is working on integrating other new technologies into the solution.

"We are currently working on the technology side by incorporating other GE products into our solution such as GE's Waukesha gas engines—engines that can run 100 per cent on natural gas. Today, bi-fuel engines are typically used but incorporating a Waukesha engine into Last Mile technology would enable operators to capture and use more previously wasted gas, displace more costly diesel fuel and reduce more emissions."

At the beginning of 2014, in collaboration with GE Ventures and Ferus, Statoil started a pilot project using the Last Mile Fueling Solution. The project sees otherwise flared gas captured and used to assist in powering the company's drilling operations.

Statoil says it has a flaring reduction roadmap that includes a number of initiatives to reduce flaring and increase gas capture. Due to the mobile nature of the flaring challenge, the company needed a mobile solution to really address the unique challenges in capturing flared gas. The expansion of the Last Mile Fueling Solution enables Statoil to tackle the current challenges related to the lack of pipeline capacity and mobility challenges of flaring in the Bakken.

Statoil recently announced that it would expand its pilot project from one system to three systems to power all six of its drilling rigs and one fracturing fleet. The company has been able to improve utilization from the first system and is working to get its remaining rigs ready to receive CNG by equipping them with pressure reduction units. The second system will be in place shortly. Statoil anticipates that with all three systems in place, it will be able to capture between three and up to five million standard cubic feet of gas per day. The project expansion would be the first step in moving into full commercial adoption of the Last Mile technology.

The results of Statoil using the Last Mile technology on its pilot project have been very encouraging, the company said. Capturing gas and using it in the company's operations to substitute up to 50 per cent of diesel not only reduces flaring but it also reduces emissions and results in cost savings. Statoil met the new flaring capture target rate of 74 per cent by Oct. 1.

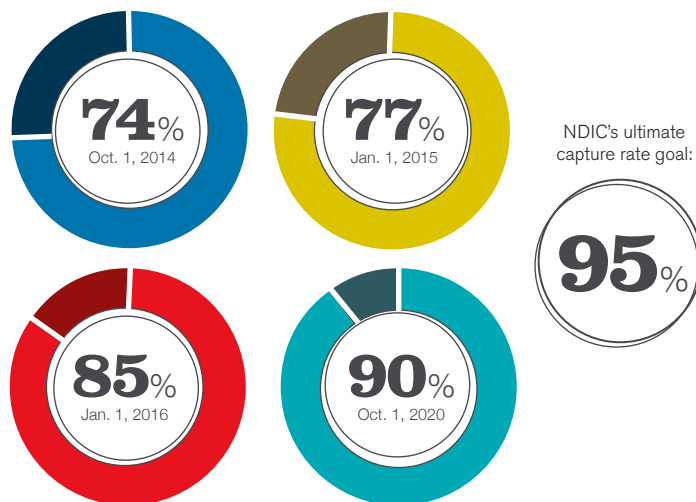
"The Last Mile technology offers us a win across the board. It enables us to capture flared gas, reduce emissions and experience a cost savings. We are pursuing several strategies to reduce flaring, however, this mobile solution enables us to hit an ever moving target and capture gas now where there is insufficient pipeline capacity," says Russell Rankin, Statoil's regional manager in the Bakken.

CONVERSION SOLUTION

LPP Combustion's patented Lean, Premixed, Prevaporized (LPP) fuel conversion technology takes a variety of light hydrocarbon gases and liquids, like those found in flare gas streams, and converts them into a natural gas substitute that can be used as a replacement for natural gas to fuel commercial gas turbine engines for power generation.

The conversion process includes heating and vaporization of the liquid components and dilution with nitrogen from the air to create a fuel gas that has combustion properties similar to natural gas. Once the flare gases or natural gas liquids (NGLs) are converted to LPP Gas in the company's fuel conversion skid, the gas can be burned in a gas turbine engine designed to run on natural gas with no change in the internal engine components.

Effective Oct. 1, producers in North Dakota must capture 74 per cent of their produced gas. The capture rate continues to increase over the next six years.



The conversion process works on a wide range of hydrocarbon compositions in the flare gas and can use the entire flare gas stream regardless of local variations in the flare gas composition, the company says. While running on LPP Gas, the gas turbine engine will provide performance and very low emissions similar to operating on natural gas. The process of converting the flare gas or NGLs to LPP Gas takes place in real time based on the fuel demand of the gas turbine.

LPP Combustion skids operate with commercially available gas turbine engines, which range from 30 kilowatts to 180 megawatts. A commercial system attached to a Capstone C30 gas turbine engine is currently in North Dakota, which provides demonstrations of operation on a variety of flare gases.

"Because the LPP Combustion technology can utilize the entire fuel content of a flare stream rather than just a small portion, our technology provides a much more comprehensive economic and emissions solution to the flaring challenge as seen in the Bakken," says Rick Roby, chief executive officer of LPP Combustion.

"Another benefit of our technology is that the solution can provide electric power at remote locations for fracking operations without the need to truck in massive amounts of diesel fuel. By not having to truck in massive amounts of diesel fuel, the cost of electricity supplied by using the flare gas is one-third to one-quarter the cost using trucked-in diesel fuel," Roby says.

"Also, the diesel engines currently used in fracking operations contribute significantly to the air pollution in North Dakota because they inherently create much greater emissions than gas turbine engines [typically at least ten times more pollution]. As well, the need to supply diesel fuel to all of the diesel engines has led to an enormous fuel supply logistical problem that has resulted in very high truck traffic and additional pollution from the diesel engines of the trucks that bring the diesel fuel to the fracking fields."

In North Dakota, LPP Combustion is responding to requests for quotes on its LPP Combustion fuel conversion skids, Roby says. The company is also touring the state with a mobile commercial unit to demonstrate its technology to companies involved in fracking operations. And they are in discussions with the Three Affiliated Tribes to provide a demonstration of its technology on their reservations. ■



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Saying No To H₂O

New fracture process aims to entirely eliminate water use

One of the biggest sources of complaints about the energy industry's shale gas and tight oil revolution is its use of large quantities of water. Its use in hydraulic fracturing causes an assortment of headaches, from the difficulty sourcing it in drought-stricken areas to the costs of handling, recycling and disposing of it, to the damage it can cause to water-sensitive formations, to the public perception its use is simply bad for the environment.

Some methods of multistage fracturing can reduce the use of water, such as substituting liquid propane or using a base of nitrogen or carbon dioxide in energized frac fluids that reduce water use up to 80 per cent.

Now the largest industrial gas company in the Americas says it can take the "hydro" entirely out of hydraulic fracturing. Danbury, Conn. based Praxair Inc. has launched a new DryFrac waterless fracturing technology that uses liquid CO₂, and no water.

The process involves a patent pending DryFrac blender technology that mixes pure CO₂ with the proppant in precise concentrations necessary for fracturing, according to Mark Weise, director of business development for Praxair's Oil and Gas Services Business. The flexible and scalable technology can deliver large volumes and multiple grades of proppant into a formation, he says. Additionally, Praxair can separate CO₂ returned from the well after fracturing. And because CO₂ is nonflammable, it is also safer than water substitutes like propane, he says.

CO₂ has long been recognized as a superior fluid for fracturing, particularly in water-sensitive or low-pressure formations. In fact, its occasional use for fracturing in the 1990s predates the shale gas revolution.

But more often than not, it is used with water in energized frac fluid, or foamed applications. "Praxair, has supplied CO₂ in Canada and in the U.S. for fracturing >

FRACKING SUBSTITUTE

Praxair field workers pump liquid CO₂ at a fracturing site. The use of CO₂ as an alternative to water provides a number of advantages to producers.



BEYOND WATER

A depiction of a fracturing site using Praxair's waterless fracking technology. The technology is particularly advantageous in water-scarce areas and in water-sensitive formations.

with foam as well, as a foam with water [is] typically anywhere from 30 to 70 quality, which refers to per cent CO₂ in the water," says Weise. "What's exciting about this is that we totally eliminate the water, and so you get that benefit of improved productivity because, even in a foam frac, there is going to be some water that may create capillary blockage in the fractures and can cause damage to the formation."

"CO₂ can also dissolve into the oil, reducing the density, reducing the viscosity, reducing the interfacial tension, which better allows that oil to flow," says Greg Pannucio, Praxair associate director.

One downside to liquid CO₂ is that it has less viscosity than water, reducing its ability to carry proppant into the formation during fracturing.

"We are looking at additives to enable us to use high flow rates and also to increase the proppant loading that will really make the process a lot more productive and effective for our customers," says Richard Kelly, senior research and development manager. "Which really means when we let the pressure off the well and flow the CO₂ back, there is nothing left behind and the well has the best chance to be the most productive."

Weise says the patent pending process has been under development for a few years within Praxair and was tested with an independent producer it could not yet name. "We took it through pilot testing towards the beginning of this year, and then we have taken it out to field demonstration within the last couple of months in a sandstone formation in Oklahoma.

"The results are still coming in, but right now it is safe to say that when we pumped the job we were able to fracture the formation with carbon dioxide, we were able to place sand, or proppant, into the formation and we are now getting very nice results in terms of oil production. As we go forward this year we expect to have a number of more jobs completed."

Praxair targeted an area where the formations are sensitive to water, where the technology is particularly beneficial. "There are clays and muds, and by using hydraulic fracturing there, the clays tend to swell or they actually cause clay migration that ends up blocking the formation, and so it is recognized that these formations are fairly sensitive and so people are looking for alternative ways to frac."

Praxair believes, however, that CO₂ could be a superior fluid for just about any formation, Weise says. "We think a lot of the unconventional plays in North America could be a good fit for waterless fracturing with carbon dioxide, and we have been talking to people in almost every one of the major plays in the U.S."

Much of the new service is nothing new to Praxair, which has been providing nitrogen and CO₂ to the oil and gas industry for about 40 years, Weise notes. "We will bring portable vessels to the field, manifold those vessels up, run boost pumps and control the flow of the CO₂ to the service company for conventional jobs. For this [new technology], in addition to that, we will bring our blender technology out to the field to blend the sand and the CO₂ together."

Most of the CO₂ the company sources is captured from industrial off-gas and purified. "We are capturing CO₂ from a manmade, or anthropogenic, sources and recycling it for fracturing. Most of our sources are ammonia plants or ethanol plants or chemical processing plants."

Total drilling and completions costs for a well fracked with CO₂ are competitive with a well fracked with water, he says. "The real value to the operator is in that there is higher initial production rates, higher ultimate recoveries, and also you avoid the sustainability issues that you have when you are working in drought-affected areas, and also the processing of the frac water that comes back [is avoided]."

■ Maurice Smith

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A 3D cutaway illustration of a wellbore. The wellbore is shown in a perspective view, with several horizontal sections. Inside the wellbore, there are numerous green and yellow bubbles of varying sizes, representing gas or fluid flow. The wellbore is surrounded by a grey, textured material, possibly rock or casing. The overall scene is set against a dark background.

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