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tech guide

VOL 5 2013

CANADIAN OILPATCH TECHNOLOGY GUIDEBOOK

- DRILLING
- PRODUCTION
- FRACTURING
- TIGHT OIL & GAS
- DATA MANAGEMENT & SOFTWARE
- HEALTH, SAFETY & ENVIRONMENT

New Technology magazine

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Technology Game Changer

Several years into the so-called shale gas revolution—one that has since spread to tight oil—it is still too early to say just how large the impact on world energy markets will be. But if North America is any indication, it will be a game changer.

The technologies developed to profitably extract hydrocarbons from tight formations like shale—primarily the combination of horizontal drilling and multistage hydraulic fracturing—have led to a remarkable reversal in the continent's previously falling oil and gas production levels. If it hadn't become apparent already, the release of detailed forecasts by some reputable agencies has driven the point home.

Not many would have predicted a decade ago that the United States would surpass Saudi Arabia and Russia as the world's chief oil producer by 2017, as the International Energy Agency now holds to be the case, or that the United States is sitting on a century's worth of natural gas (at current consumption levels), as the National Petroleum Council determined in a 2011 report for the U.S. Department of Energy.

But while the impact of technology to extract oil and gas from tight formations has turned the supply situation upside down, perhaps less appreciated has been the spinoff effects of the oil and gas boom as the benefits have spread well beyond the oil and gas production sector. The impact is leading to a reawakening of the manufacturing and petrochemical industries as they benefit from cheaper fuel and feedstock as well as increased demand for products needed to feed the boom.

"An underappreciated part of the shale gas story is the substantial cost benefit to manufacturers, based on estimates of future natural gas prices as more shale gas is recovered," PricewaterhouseCoopers LLP stated in a report, *Shale Gas: A renaissance in US manufacturing?* The report says the cost savings to U.S. manufacturers could amount to $11 billion annually while bolstering employment by one million new jobs by 2025.

RBC Capital Markets and the Economist Intelligence Unit came to some similar conclusions in a report released in February, concluding a paradigm shift is underway in the way that businesses and national governments look at energy stemming from the shale gas boom. Low-cost shale gas will be especially beneficial to companies that rely on feedstock or direct energy usage to compete, the report stated. "In industries like petrochemicals and fertilizers, where feedstock or energy inputs can account for up to 90 per cent of total production costs, low-priced shale gas will be a game changer," it said.

According to a 2012 IHS Global Insight study, unconventional gas activity alone already supported more than one million jobs in 2010, and it will grow to support nearly 1.5 million by 2015. Nearly $3.2 trillion in cumulative investments in the development of unconventional gas are expected to fuel the increase in production between 2010 and 2035, it forecast.

In addition to the spreading economic gains driven by upstream technologies that have unlocked light tight oil and shale gas resources has come an unexpected benefit to the environment. The switchover to natural gas from more polluting fossil fuels like coal has led to the United States, almost by accident, topping the European Union (EU) by some measures in reducing greenhouse gas emissions, despite all the efforts the EU has engaged in to reduce them—albeit from already lower existing levels.

It is still an open question whether the shale oil and gas revolution will spread very far beyond Canada and the United States, which had the preconditions most conducive to developing the resources. And even here, there are challenges still to overcome as the industry deals with such issues as its high water demands, rapid decline rates and public concerns over the perceived dangers of fracking.

But those are, in many respects, technological challenges that can be solved with innovations and advances in technology now under development and yet to be discovered. In this guide, we look at some of the latest and greatest of those advances, and others in the areas of data management, software and environmental protection, being rolled out into an industry that appears set to power the continent forward for decades to come.

■ ***Maurice Smith***

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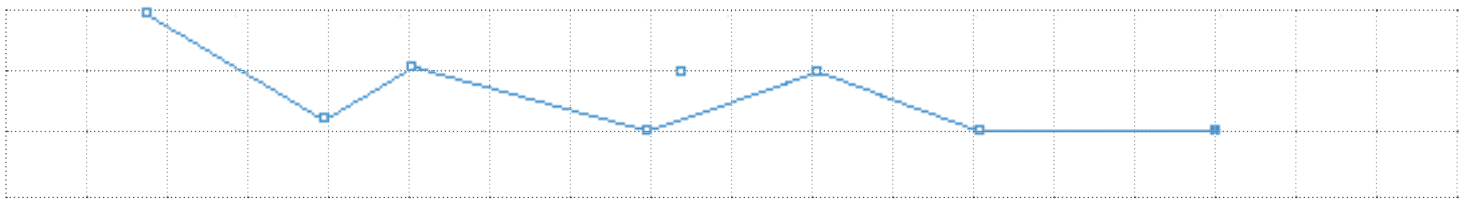


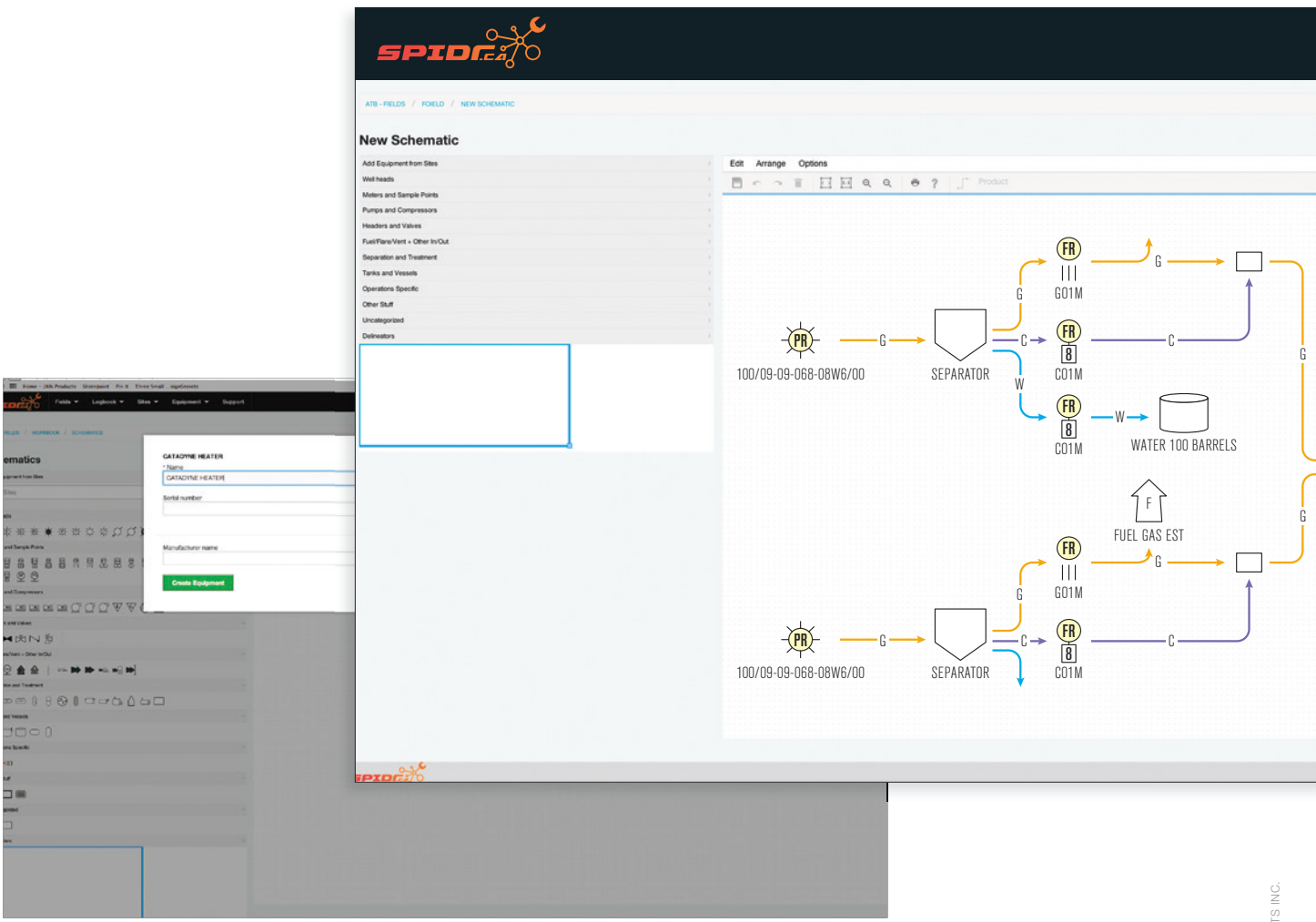
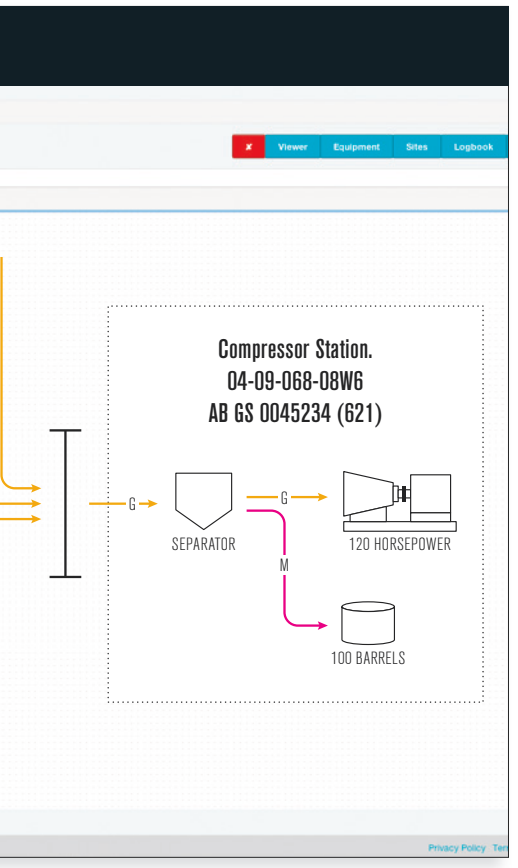


PHOTO: MUDDY BOOTS INC.

Web-based software simplifies measurement schematics ahead of updated regulatory requirement

BY PAT ROCHE



▲ SCHEMATIC SIMPLICITY
Hosted in a state of the art data centre and implementable without support, Muddy Boots's SPIDR.ca schematic manages measurement schematics in a searchable, secure format.

Two big challenges for oil and gas producers are complying with increasingly complex and stringent regulations and knowing exactly what equipment they have and where it is. A new tool created by Calgary oilpatch software entrepreneur Bruce Holman is designed to make both of those tasks easier, at least as it relates to measurement schematics.

Measurement schematics are diagrams showing the physical layout of facilities, tracing the flow of production as it moves between the wellhead and the sales pipeline. Components include pipelines, valves, meters, separators, treaters, flare points, dehydrators, compressors, sweetening units and refrigeration units.

While accurate, up-to-date information is inherently valuable to a company, there is also a regulatory push for producers to get their schematics in order.

The Alberta Energy Regulator's 329-page Directive 017 consolidates, clarifies and updates the province's measurement, accounting and reporting requirements for oil and gas operations. The requirement that producers have measurement schematics for all their facilities takes effect in September 2014.

Industry users interviewed for this article were happy that Holman's measurement schematics software is web-based. In other words, it is only installed once in one place—on the vendor's server. Customers access it over the Internet. Since there's no in-house installation, there's no in-house administration or maintenance.

For his part, Holman has already chalked up one big success for web-based software in the Canadian oilpatch. He was technical lead on JIBLink, which began as a start-up in 2000 and became the industry standard for joint interest billing. "I'm taking a lot of the concepts from the 10 years that I spent there—security, ease of use—and applying the same principles to the new venture," he says.

His new oilpatch software venture—which is providing the online measurement schematics software—is called Muddy Boots Inc. "We want to make sure everyone who works for our company understands a day in the life," he says of the Muddy Boots moniker. "The concept is whoever works for the company spends time out in the field, whether you're helpdesk or what," says Holman, president of the new company.

Holman says this grassroots approach to software development worked well on JIBLink. "We all spent a lot of time sitting with folks, helping them enter data, going to their office when they had an issue and sitting right with them to understand exactly what their day looks like. And it made a huge difference on the design of the product."

When he decided to create the online measurement schematics software, Holman contacted people such as operations mangers and vice-presidents of operations to find out exactly what they wanted. "All they really want to know is: what do I have? And where is it? Every person wanted to know that information and didn't have it," he recalls. He was referring to a producer's master list, an inventory of all its major pieces of equipment and the locations where the company operates. So Muddy Boots "defined" an online master database. ►

LACK OF CONSISTENCY

Operators create schematic drawings using tools ranging from Microsoft Visio to paper. Schematic metering diagrams can be done differently in different areas of a company.

"The data is sometimes in Excel spreadsheets, sometimes it's in AutoCAD files and it can be dispersed across the enterprise with different people responsible for ensuring that schematic metering diagrams are kept up to date, and everybody solves the problem a little bit differently," says Gregory Tink, a consultant with Streamline Control Solutions. The consultancy, which helps oil and gas producers streamline their data flow and business processes, has trained staff on the Muddy Boots software to help clients get their data in order.

"What we really like about Muddy Boots," Tink says, "is it brings the data into one data source."

Streamline Control Solutions worked with one client where three different areas within the company were keeping their schematics in three different ways—two were using different Excel spreadsheets and a third area was using AutoCAD.

"What usually happened," says Tink, "was the person that knew the most about what these schematic measurement diagrams were supposed to do was put in charge of figuring out the problem and then moving them forward. So you would have whoever was in that area just basically solving the problem on their own without talking to the other areas. But because historically there weren't a lot of tools you could draw upon, people just solved the problem 20 different ways within the same company. With tools like Muddy Boots, now you can have a central way of doing it."

Muddy Boots's online schematics website is called SPIDR.ca. While the SPIDR.ca software was created as a schematic tool—you can draw and have a visual representation of your operation—it is also a database, an online inventory of a producer's major pieces of equipment and its locations.

Once the schematics data is in a secure online database, authorized employees can access it. "You don't have to know AutoCAD. You don't have to have someone who can run a query form a database," says Tink. "Also, if you're in one area and you move to another area, you can find the data for that other area real easily."

In fact, SPIDR.ca may have as much value as an electronic database as it does a schematic tool, some suggest.

Keeping all of a producer's equipment—and all the specifications of that equipment—in a single electronic database is "a huge savings in time, effort and money over your traditional methods of schematic building," says Brian Stanko, who was a production accountant for 24 years before becoming a consultant.

> *"We want to make sure everyone who works for our company understands a day in the life. The concept is whoever works for the company spends time out in the field, whether you're helpdesk or what."*
>
> — Bruce Holman, president, Muddy Boots Inc.

Because the traditional methods of schematic building were so time consuming—and hence costly—most people didn't bother, says Stanko. He began using the Muddy Boots software about three months ago while helping a client company that was using SPIDR.ca to build its schematics to meet the requirements of the Alberta Energy Regulator's Enhanced Production Audit Program.

KNOWING WHAT YOU HAVE

Calgary-based TORC Oil & Gas Ltd., a publicly traded producer with average first-quarter output of 4,240 barrels of oil equivalent per day, is using SPIDR.ca to address its need for detailed property schematics for both internal control and regulatory compliance. "We have found SPIDR.ca flexible in its design and easy to use," says Stuart Woodhouse, TORC's manager of production and revenue accounting. "As well, the support provided by Muddy Boots has been exceptional."

Like most smaller producers, TORC previously hadn't been using any schematics software. "We were embarking down a path of just using an Excel template. It was cumbersome and had some of the limitations of a spreadsheet-type application," Woodhouse recalls.

Privately held Sogar Resources Ltd., a small but long-established Calgary producer, also found the online schematics tool helpful.

"As a small producer, we're always struggling with keeping up to technology and keeping up with requirements for compliance [with Alberta's oil and gas regulations]," says Ron Bobyn, president of Sogar Resources. One area where this was particularly challenging was schematics, and that's where Muddy Boots came in.

"We sat down with them and went through every single well and facility we have, and we learned a lot throughout the process about what we actually have," recalls Bobyn. "Because it forces your operator to look at every piece of equipment from when the pipe comes up out of the ground to when it goes back into the ground. So it's a very good tool to allow you to track what's at each site, what the vintage is of each vessel or each component of any facility you have."

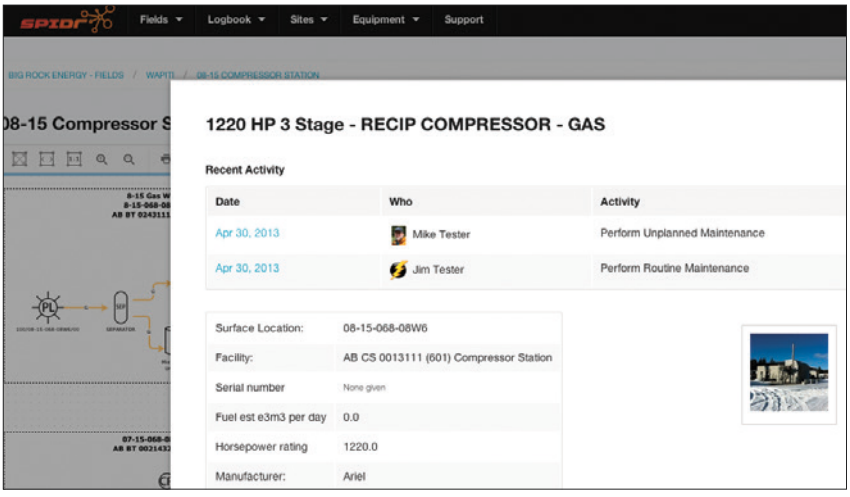
Bobyn says Muddy Boots provided training and helped Sogar Resources staff build their schematics. "Once we were done and everything was up and running, we ran it past our field superintendent who walked around with that exact schematic at the facility and verified everything that was there," says Bobyn. So now the operator in the field has a complete schematic showing exactly what equipment is where, when it was installed and its specifications. "If you have a failure, you know what's on the lease."

He says SPIDR.ca provides a paper trail in case of audits. If regulators want to know, for example, the frequency of inspections required on a pipeline, the records are easily accessible. Inputting all this data is time consuming, he acknowledged, "but once it's in, it's in."

And it's useful for more than regulatory compliance. "You're assessed, for example,

KEEPING TRACK

SPIDR.ca allows for easy navigation through large schematics and from one schematic to another with flow in and flow out links, as well as photo views of equipment directly from the schematics.



property tax by every county. And you have to pay according to what you have at surface—tanks, compressors, facilities, whatnot," says Bobyn. "So you need to know what is at every facility. And Muddy Boots software allows you to do that."

Each producer's data on SPIDR.ca is accessible only to the authorized employees of that company, of course, but there would still be advantages in having many producers plugged into the same database. "With so many acquisitions and dispositions in this industry," Bobyn says, "there has to be some central device that allows people to know exactly what they're inheriting or disposing."

But the real strength of SPIDR.ca, he says, is to enable engineers to see exactly what's at each facility when planning changes or designing upgrades. "Every vessel and every piece of equipment out there has an expiry date. So it's good to know what is at each facility rather than flipping through well files that are sometimes a foot and a half deep to find that one piece of paper that says this one little vessel was built in 1989."

WEB-BASED

Stanko says the fact that SPIDR.ca is web-based is a "huge plus."

"Because it's online, the software is constantly being upgraded and improved," says Bobyn. "If you have it on each desktop, it's not being updated and supported. If you have it online, they're maintaining your database for you and you can access it anywhere."

If software is installed on a customer's server, on the other hand, then each company using it has to do its own administration. The IT department has to get involved every time there are upgrades or updates. Muddy Boots takes care of all the administration of its software, which its customers access through ordinary web browsers such as Google Chrome.

"Because it's a cloud-based system, you can literally have people start using it tomorrow," adds Tink. ("On the cloud" is tech-industry jargon that means files or applications are stored on remote servers and accessed over the Internet instead of residing on each user's hard drive or in-house server. Yahoo! Mail and Google Docs are examples of cloud-based applications.)

"The whole intent is ease of implementation," says Holman. "All you need is a web browser. You don't need to establish the infrastructure within your own IT environment. All that is managed by us.... When we upgrade the software, everybody gets the upgrade without the upgrade project. If there's a bug fix that has to be put up, we can patch that immediately."

Stanko says the SPIDR.ca software is also easy to use. "It's very simple...yet there's a lot of information at your fingertips.... Putting info in and pulling info out is as simple as an Excel spreadsheet."

So how powerful is this web-based software?

"I believe it will handle most situations for most producers," says Stanko. "Could you build a complex gas plant with it?... You probably wouldn't want to do that." But the consultant points out that even large companies have very few of those. "The vast majority of their production is still going to be simple properties." He estimates SPIDR.ca will handle 98 or 99 per cent of the tasks for any size of producer.

Stanko views the SPIDR.ca software as a good trade-off between ease of use and the ability to do everything for everyone. He believes a one-size-fits-all approach to software design—where the same package is expected to handle both the simplest and the most complex situations—ends up being too complex for the 99 per cent of users who never need the high-end features.

"That's the beauty of SPIDR," he says. "It's simple, it's easy to use and it's intuitive. There are only a few basic icons. They're displayed nicely. They make sense. And it will do most everything for most everybody."

Adds Tink, "It's fairly easy to take that data, no matter what format it's in, and get it into Muddy Boots's tool and start using it, start analyzing the data and expand on it and use it as part of your daily processes. Whereas before, if companies were using that data, they would find it difficult to get any sort of value out of it other than [to] keep it up to date."

So he has no problem recommending it to clients.

"In a lot of cases, we were brought in to solve problems like, What do we do with these schematic metering diagrams? The [Alberta Energy Regulator] is asking us to have a better handle on it, and we need to figure out how we can move forward,'" explains Tink.

"And we'll try to point them to a tool that can help them as opposed to continuing with Excel and AutoCAD," the consultant says. "A tool that's specifically built for schematic metering diagrams—and allows you to centralize your data—is obviously going to be better than creating something on your own that you may have 20 versions of." ■

PHOTO: MUDDY BOOTS INC.

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Software Survey 2013

Welcome to *New Technology Magazine*'s 11th annual software survey. This survey is designed to provide our readers with a guide to some of the applications that can assist oil and gas producers with a range of functions—from exploration to drilling to reservoir characterization to accounting. In addition to a description of the application, software providers have listed new features available with new or future versions.

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Software Description:
The Well Completions & Frac Database provides digital completions and fracturing data for all Western Canadian Resource Plays including the most recent Duvernay, Southern Alberta Glauconitic and Second White Specks wells. With its powerful online interface, users can identify trends and common practices, optimize completions programs, benchmark competitor performance and increase understanding of costs and risks. Rigorous QA/QC procedures ensure reliable, value-added data. As of June 2013, the database contains over 22,000 wells and includes detailed well reports with direct links to bookmarked PDF source documents (D & C Tour Reports).

Application Features:
- Fully searchable – basic to advanced query capabilities
- Analysis ready – multi-variable graphs, charts, lists and summaries
- Fully exportable – Excel, Visage, Spotfire, ArcGIS

Key Data:
- Job objective, costs, time
- Technology, frac/stimulation fluid, # stages
- Proppant placed, fluid pumped
- Resource Play, producing zone, operator, stimulation company

New Features:
- DDAoption – synchronizeWCFD data with in-house/third-party databases and applications

Software Description:
The EDGE screening tool is used to quickly and reliably investigate geology, operators, activity, production, reserves and costs across Western Canada. Instantly create summary reports complete with graphs, maps and schematics, or generate custom graphs and lists.

Software Functionalities:
- Compare and contrast operator performance
- Benchmark plays, areas and producing zones
- Research industry activity and trends

The EDGE contains multiple datasets for all wells rig released since 1995, including a Canadian Discovery geological play assignment for every well event. Production, reserves and play metrics data include:
- Average initial production
- Average/total present and cumulative production
- Average/total ultimate recoverables
- Resource type assignments
- Average cost/BOE

Innovative Reporting Features:
- Quarterly Play Statistics Report - provides comparable results, metrics and supporting geology for every play in the basin
- Instant Report - a detailed, results-based overview for any area, operator or play.
- Fully-indexed and searchable Resource Type Maps and Descriptions – e.g. Conventional vs. Unconventional

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interCALM

interCALM (Integrated Capital Lifecycle Management) provides the methodology to help you uniformly manage the most important parts of your business. With integrated budgeting, forecasting, AFE, RTD and resource scheduling, there is no other tool that brings together more business processes into one centralized application. Aside from the significant cost savings of replacing several disparate systems with one, interCALM simplifies the jobs of project teams and provides the truth in the numbers that management, directors and shareholders today demand.

interVIEW

interVIEW is a finance-focused application that enables oil & gas companies to put a complete financial face on their capital plan and operating activities. In addition to capital and volumes, interVIEW covers revenue/price modelling, royalties, detailed fixed/variable operating expenses, G&A, debt and cash flow modelling. It provides complete income statement, balance sheet and cash flow statements all in one accessible, affordable and easy to use application.

royaltyITS

With distinct allowable time limits to legally collect, it does not take long for royalty revenue to become a write-off. The royalty Income Tracking System identifies missing receivable revenue from all of your royalty interests, and allows you to track discrepancies through to collection. Between complete royalty income calculations, organized issue tracking, and powerful management reporting, royaltyITS provides the foundation for the due course and strategic management of your historical, current and future royalty interests.

New Features:
- interCALM 6.5 (released June 4th, 2013)
- AFE Generators Enhancements
- Enhanced handling of revisions and supplements and streamlined notifications both inside and outside of the application.
- AFE Accruals
- Built in capital accruals engine (project information with Field Estimates, AFE estimates and incurred costs to date). Accruals electronically uploaded to your accounting system.
- Overhauled Resource Scheduler
- Click-and-drag functionality to schedule activities (such as drills) with a complete overhaul to improve performance and usability. Scheduling is simplified with the ability to view a single rig, a group of rigs or all rigs.

- New Reports
- Capital Breakdown Report – displays capital grouped by geographical area and type
- Production Wedge Report – users can view base and incremental wedge for the upcoming year, and any number of years into the future, to deliver a long-range forecast.

Future Versions:
- interCALM Capital Dashboard – User configurable to include access to critical information such as KPIs, capital and production look backs, budget to actuals, budget/forecast comparisons and current capital picture.
- Enhanced long-range planning
- Build out your LRP – 5-10 years and beyond
- Additional Reports
- Full suite of capital and production comparison reports Current plan vs. previous forecast vs. budget.

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Enersight creates business planning solutions for the petroleum industry. Enersight's software is a web-based upstream oil and gas field development planning, scheduling and economics tool. In 2013 Enersight has added two additional products to their modelling suite – Operational scheduling and Enersight Enterprise corporate planning solution.

Enersight Planning – Field Development Modelling

Enersight Planning (previously known as WellSpring) lets you build a complete picture of your production network of wells and gathering system and incorporate a development plan with production profiles, drilling schedules, facility sizing and capital.

Features:
- Planning and continuing field optimization
- Constrained flow throughout network
- Budgeting well numbers, plant capacities, rigs and other key inputs
- Analysis of actual spending and performing look backs
- Tracking plan changes
- Revision of estimates, creating a "rolling business plan"

Enersight Planning is used by oil and gas companies of all sizes to help make their toughest development decisions including SAGD project scheduling, shale gas development, CO_2 flooding and large conventional projects.

New Features for 2013:
- Direct tie in to Enersight's Drilling and Completions Scheduling
- Ability to forecast production on a daily basis, allowing for an accurate whole field production forecast
- Ability to assign drilling rigs by area

Enersight Enterprise – Corporate Planning

Enersight Planning efficiently calculates detailed project schedules taking into account multi-step drilling programs, rig availability together with the surface flow network. Enersight Enterprise takes this detail, and delivers it in a structured form to a corporate level. Using this structured data, Enterprise allows companies to track project value over time – quantifying changes in production and value, and also what caused those changes.

Features:
- Ability to track value and volume over time
- Compare forecast to actuals
- Update production outlook yearly, monthly, quarterly or even weekly
- Pinpoint exact changes and reasons for change (schedule, forecasts, capital)
- Aggregate plans across the corporation
- Apply capital budget constraints automatically to projects

New Features for 2013:
- Ability to connect to the Enterprise data store and pull detailed result and schedule information using Enersight Connect directly into an Excel spreadsheet
- Ability to track production and value over time
- Ability to consolidate all Enersight projects into a single view

Enersight Operational Scheduling - Drilling and Completions Scheduling

Enersight's Operational Scheduler allows teams to manage all pre-drilling steps, rig scheduling, and completion services in one cohesive Gantt Chart view. This module gives you daily and weekly scheduling forecasts for all rigs, drilling locations and other resources.

Features:
- Track permitting, regulatory steps, well licences, site restrictions, etc.
- Manage resources on a daily basis
- Inform field engineers about upcoming activity in their area
- Track activity information to quickly identify delays/ disruptions and make adjustments
- Integrates your short term schedule with medium- and long-term plans

New Features for 2013:
- Ability to graphically display a detailed Gantt chart of drilling rigs, pre-drill steps and frac schedule by well
- Ability to right click on the Gantt to update the well status
- Updates are tied directly to short and long term Enersight plan

entero®
energy software

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For more than 19 years, Entero has provided clarity and efficiency to the energy industry's critical business functions through its Entero® ONE™ and MOSAIC™ software solutions. Entero works closely with over 150 clients to deliver better productivity, trusted information, superior insight, and significantly reduced cycle times on key business processes. Entero clients span the largest producers and marketers, to leading consulting and financial firms, to small or mid-sized operators.

Entero MOSAIC™

MOSAIC is used by engineering, reserves, budgeting, capital planning, and A&D groups to deliver a complete picture on company value. It is a comprehensive application that can evaluate anything from large corporate portfolios to individual reserve assets. Many energy organizations are switching to MOSAIC™ to benefit from better functionality, more efficient processes, easier collaboration, database stability, great service, and quick database conversions.

New Features & Future Versions:
Recently released, MOSAIC v2013 is Entero's strongest and most complete offering yet. The system continues to put clients one step ahead with key functionality to facilitate workflows for reserves, budgeting, A&D and project economics. It enables engineers, evaluators, and corporate analysts to work as one with confidence – faster and with less effort than ever before. MOSAIC v2013 includes a suite of unconventional planning and analysis tools, critical capital tracking capabilities, easy "look back" and archiving tools, powerful data comparison tools, and speed enhancements across UI, calculations, and reporting functionality. Visit the website to learn more.

Envirosoft

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Emission Manager™

Emission Manager™ (EM™), a leader in emissions data management, is a web-based data management system and emissions calculation tool, designed specifically for the oil and gas industry. Based on published CAPP and API methodologies, EM™ provides a unique solution for the calculation, tracking and reporting of facility- and corporate-level greenhouse gas (GHG) and criteria air contaminant (CAC) emissions, as well as GHG emission intensities. Various "connect" utilities facilitate the upload/download of information to/from other systems.

New Features & Future Versions:
Reports have been added and enhanced, e.g. new "Equipment Configuration and Emission Factors" report, new "Facility Data - Monthly" report, and enhanced "Emissions Report," which includes a breakdown of Pneumatics emissions by Pneumatic device type. Combustion equipment information management has been further optimized.

A U.S. version of Emission Manager™ has been launched to assist American oil and gas clients in meeting the reporting requirements under the U.S. EPA Greenhouse Gas Mandatory Reporting Rule.

Fuel Flare Vent Manager™

New in 2013, Fuel-Flare-Vent Manager™ (FFVM™) is a web-based data management solution for the estimation and management of unmetered fuel, along with unmetered flared and vented volumes from both routine and non-routine sources. FFVM provides a valuable business control process to raise the level of assurance regarding operators' compliance with measurement and reporting requirements, and meets the objectives outlined in Directive 076 and the AER's Enhanced Production Audit Program (EPAP).

New Features:

- System is accessible to multiple users simultaneously.
- Eliminates calculation errors and drives consistency and transparency of how volumes are calculated.
- Generates flare and vent log reports, and production accounting reports on demand. Efficient maintenance of historical records.
- An Operator Sign-Off feature locks down field data at the end of each month, indicating to production accountants that the data is ready to be reported.
- Provides capability for data integration with other systems.

Dehy Manager™

Dehy Manager™ (DM™) is an effective web-based data and project management solution for the collection, compilation and storage of dehydrator operating parameters, laboratory analytical data and public review/notifications, in addition to the current and historical operating and emissions information for glycol dehydrators. The software is also able to model the emissions and create the Dehydrator Engineering and Operations Sheet (DEOS). Furthermore, users can generate the Dehydrator Inventory Report that must be submitted to the various regulatory agencies on an annual basis.

Future Versions:

Potential compliance concerns (e.g. estimated benzene emissions greater than limits) are already visually apparent. DM™ will now take into account the updated benzene emission limits presented in the revised Directive 039 (Alberta), which come into effect in 2014. Several new reports will assist clients in identifying those dehys and sites which may require immediate attention. A new template will facilitate the upload of outputs from other modeling systems (HYSYS®, ProMax®) into DM™.

Regulatory Document Manager™

Regulatory Document Manager™ (RDM™) is a web-based repository for a company's facility licence and environmental approval documents. Oil and gas clients gain access to their regulatory information over the internet, while Envirosoft gathers and stores the information and documents on their behalf. Clients have access to a facility's regulatory history (including licences, amendments and associated Directive 056 Application Schedules), increasing confidence that the most current facility regulatory information is being viewed for decision-making purposes.

Future Versions:

There are plans to incorporate facilities' noncompliance history and related enforcement actions into RDM™.

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FacilityStudio data-driven measurement schematics solution

FacilityStudio has revolutionized the way measurement schematics are generated, maintained and used. Driven by GuildOne's innovative SynergyDNA technology, FacilityStudio automatically captures and validates data from public and proprietary systems. Delivered through one accurate source, it transforms this data into a digital representation of facilities and provides enterprise-wide value through automated workflow and ability to use this data to identify new information assets that can be used to enhance business performance.

SynergyStudio data exploitation solution

SynergyStudio transforms complex data collected from various systems into valuable information assets that are easily understood, shared and exploited to enhance business performance. Driven by GuildOne's innovative SynergyDNA technology, SynergyStudio has the power to automatically generate cross-system reports using current data to facilitate an enterprise wide unified view of information, automate workflow management, and elevate collaboration.

Future Versions: FacilityStudio 2

Enable compliance. Improve operational efficiency.

New Features:

- Bundled reports assist in compliance efforts, including Alberta Energy Regulator (AER) Directive 017 and Enhanced Production Audit Program (EPAP) requirements, and provide valuable insight into facilities.
- Automated workflow and version tracking ensures drawings are current with regulatory filings, verified regularly, and accurately tracked.
- Future developments are focused on customization to better support unique client needs and provide even greater enterprise-wide value.

SynergyStudio 4

Enhance performance. Elevate collaboration.

New Features:

- Automated workflow generates change notification and mandatory approval tracking.
- Version control automatically tracks and stores all report versions.
- Web-based reports enable convenient access to information via web browsers.
- Mapping creates a visual representation of data, providing a more collaborative output.
- RESTful based web services API allow third-party applications to connect directly to SynergyStudio.
- Future developments include a variety of pre-built solutions to provide clients with more options to choose from.

IHS

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IHS AccuMap®

AccuMap delivers tightly integrated information and functionality to support exploration and development in the Western Canadian Sedimentary Basin and Frontier areas. Well known in the industry for its ease of use, rich datasets, AccuMap provides you with the ability to work through a play from discovery to production, within one application. AccuMap provides desktop access to numerous up-to-date databases, including Mineral Land, Geology & Geophysics, Engineering, Midstream and Surface/Near Surface.

New Features & Future Versions:

Shaped by customer feedback, the new IHS AccuMap hits customer desktops this September. Customer feedback has guided our development ensuring that the new AccuMap compliments your daily workflow by providing a more powerful and intuitive interpretation solution for you. Experience transparency across all layers, create user-customizable contours, customize units for data types and visualize side-by-side comparisons! Please look for opportunities to get training through lunch and learns, WebEx and user groups in September.

IHS Kingdom®

Kingdom provides geoscientists and asset teams the functionality needed for all aspects of their portfolio management. From prospect to production, basic and advanced interpretation to microseismic analysis and geosteering, Kingdom enables faster interpretation and modeling, sharing of complex data and more confident decision making.

New Features & Future Versions:

Kingdom now offers Dynamic Depth Conversion feature that allows users to easy construction, maintain and display of time data in the depth domain. The process of building and updating velocity cubes is normally time-consuming and prone to errors. This truly advanced system revolutionizes traditional velocity modeling workflows by allowing interpreters to complete work in a fraction of the time with greater accuracy and confidence. Future releases will provide improved geosteering functionality and a direct connection to Schlumberger's Petrel Software.

IHS Petra®

Petra is an easy-to-use, integrated application with a common database and interface for project and data management, well log analysis, mapping, cross-sections, production & reservoir analysis and 3D visualization to optimize the reservoir from discovery to reserves management and to identify recompletion opportunities. Geologists, production and reservoir engineers,

geophysicists, geoscience technicians, project managers and business analysts can all benefit from using Petra.

New Features & Future Versions:
Petra recently made some usability improvements. Users can now leverage multiple WMS servers with transparency settings along with a new tree view of servers and layers in the imagery settings window. Future releases will continue to solidify the integration with Kingdom.

GDM Oil & Gas Pipeline Network

Product Overview: Together with GDM, IHS offers the GDM Oil & Gas Pipeline Network which is the industry's first comprehensive connected network of wells, pipelines and facilities for Western Canada that gives customers instant access to information never before available. We not only help you understand your pipeline inventory, we help you to manage your networks and their associated risks.

New Features & Future Versions:
Released in February 2013, the GDM Oil & Gas Pipeline Network is now available so that you can visualize your assets in context with its environment. In conjunction with IHS datasets such as Well and Production information and Enhanced Culture, the GDM Oil & Gas Pipeline Network shows a holistic look into current systems to be ahead of regulations and provide an opportunity to proactively manage well, pipeline and facility assets.

IHS Connect™

IHS Connect is an innovative new market and business intelligence platform, placing the power of our global research, analysis and forecasts at your fingertips—when and where you need it. An intuitive interface, Connect enables business decision makers to discover, analyze, visualize and integrate IHS information and insight to quickly advance your next decision.

New Features & Future Versions:
IHS Connect will launch several innovations this fall, including an intuitive global M&A analysis tool and expanded functionality for accessing our Economics & Country Risk reports content and forecasts.

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Intergraph® PP&M division creates solutions that enable design, construction and operation of process and power plants, offshore platforms and ships, and provides the information management capabilities to build and operate facilities. Intergraph is ranked the number one overall worldwide leader in the engineering design 3D software and process engineering tools market according to ARC Advisory Group.

SmartPlant® Fusion

SmartPlant Fusion is the latest solution to rapidly capture, organize and repurpose large volumes of unstructured information through a simple web portal interface. This information may include documents, drawings, lists, 3D models and link to High Definition Survey laser scans. This 'as-exists' information asset is a vital but often undervalued representation of a plant or project. Organizing and keeping track of this information on a brownfield plant site is challenging, particularly during updates, revamps and turnarounds. This is the same for greenfield construction projects dealing with large volumes of unstructured information from multiple sources.

SmartPlant® Construction

Major construction projects involve thousands of workers, millions of details and numerous complex variables including labor, materials, weather and schedules. How can you manage billions of bits of data to complete the project on time and budget? How can you turn improved information management into increased field productivity? The challenge for the construction industry is determining how to make informed decisions based on the most accurate information available and manage people and materials in a dynamic construction environment to advance the project in the safest and most efficient manner.

Intergraph's SmartPlant Construction meets specific needs of construction companies, project management offices, fabricators and owners in managing construction resources, materials and schedules. Intuitive, configurable interfaces enable work package planners to create effective work packages using industry-proven work processes. Real-time material integration availability reports provide dynamic re-planning capabilities and a configurable planning window enables planners to make economical modifications before problems grow.

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Asset Management Inventory Control System (AMiCS) software

AMiCS is a secure, web-based software specifically designed to help oil & gas companies locate, view, track, manage and transfer production equipment. AMiCS is equipment centric, enabling companies to:

- Redeploy equipment, reduce duplicate spending
- Monetize Surplus assets
- Attach pictures, drawings, manuals, etc. to each equipment record
- Manage equipment valuations for joint venture accounting, insurance and property tax purposes
- Maintain financial and management control of your assets
- All updates in real time

New Features & Future Versions

- Customized to the unique needs of each user company; mimics internal workflow processes
- Searchable fields i.e., location, serial number, boilers branch number, manufacturer, federal registration number, property code, etc
- Uses Petroleum Accountants Society of Canada (PASC) terms
- Provides an audit trail for Sarbanes-Oxley (SOX)
- Compliant with International Financial Reporting Standards (IFRS)
- Material Transfers track your equipment
- Interfaces with Asset Integrity Management solutions
- Multiple reports
- Exportable to Excel

MJ SYSTEMS

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Logsleuth

MJ Systems' Logsleuth software is a Windows-based application to manage all of the raster logs that a client purchases from MJ Systems. This powerful log viewer also includes the survey systems for most of North America so clients can quickly search, display, correlate and print raster logs from anywhere in Canada and 27 US States. Logsleuth also links up with geoSCOUT, Geographix, Petra, Neruasection, SMT and others so clients have the option to move logs around to their mapping or cross-section programs of choice.

PANDELL

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Pandell is a software solutions company that has been delivering industry specialized software products and business services to market since 1997. Today, the company serves more than 350 organizations across North America with its financial and land software suites for junior, intermediate and enterprise E&P companies, major pipeline operators, and public utility companies. With over 470 product installations and 2,500+ users, Pandell's oil & gas software is the #1

market leader in the Canadian upstream oil and gas industry.

Financial Software Suite

Pandell's financial suite of software products delivers enhanced information management and workflow automation to E&P companies that includes solutions for AFE management (AFENexus), A/P invoice management (APNexus), project economics (EANexus), financial accounting (JVNexus), and production accounting (PANexus).

New Features & Future Versions:

- AFENexus: Direct integration with JVNexus including 2-way transfer of budgeting, AFE, AFE Cost Center, and DOI information. The upcoming release will be redesigned on Pandell's latest web-based platform.
- APNexus: Launched in early 2013, AP is an all-new web-based electronic invoice management solution to manage a company's entire invoice process.
- EANexus: Modernized user interface, a redesigned calculation engine and improved workflows within the economic module.
- JVNexus: The upcoming 2013 release of JV will be re-energized with an all new back-end to become even more user-friendly for enterprise companies.
- PANexus: A more intuitive interface, redesigned dashboard and the beginning transition stages to Pandell's web-based technology platform.

Land Software Suite

Pandell's integrated suite of land software products can manage an E&P company's entire land division. The suite includes Canada's premier fully web-based land solution for managing mineral leases & contracts (GeoNexus), and five "surface specific" land information management software applications that improve a company's document control (Landscape).

New Features & Future Versions:

- GeoNexus: All new interface, integrated split screen, new copy & link feature & enhanced cross-browser functionality.
- Landscape: Launched in late 2012, the solution is a set of surface land applications delivers automated workflow and detailed information management of your roads, crossings, divestments, project files and stakeholders.
- Roads provides detailed management of your lets and takes agreements and related road use activities.
- Crossings simplifies the management of your right-of-way arrangements.
- Divestment automates property disposition processes by using consolidated project data from your land system.
- Projects delivers full file lifecycle management of all surface project activity.
- Stakeholders gives real-time, mobile field consultation management using your iPad, tablet or laptop.

Paradigm®

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SeisEarth

SeisEarth is a fully integrated, multi-survey, regional-to-prospect interpretation and visualization suite. It is a fully integrated system. SeisEarth uses efficient volume roaming, automatic picking and high levels of interactivity to handle very large, single or multiple 2D and 3D seismic surveys containing multiple well databases. It supports interpretation of both post and pre-stack seismic data. SeisEarth supports multi-user interpretation. Regional projects can be created using seismic interpretation from local projects without creating copies.

New Features:

SeisEarth has received many updates during 2013. Interpreters now carry out structural, stratigraphic and multi-attribute quantitative interpretation workflows in a single application. These include advanced multi-attribute blending, volume cross plotting, GPU-based voxel rendering and pre-stack interpretation, all in the same 3D Canvas. Stratigraphic interpretation workflows have been enhanced to include interactive horizon and proportional slicing. For development and unconventional fields, SeisEarth now supports full time-dependent production information, completions data and engineering data.

EarthStudy 360

EarthStudy 360 creates a wealth of seismic image data, decomposed into in-situ full-azimuth angle-dependent reflectivities and directional data components that can be further processed to secure high-resolution images of the subsurface. These images reveal optimal information for anisotropic velocity model determination, and provide details about subsurface objects such as faults and fractures, illumination directions, and other properties of the subsurface. EarthStudy 360 is particularly effective in unconventional gas plays and fracture carbonate reservoirs.

Geolog

Paradigm Geolog provides a full set of tools for petrophysical and geological analysis, formation evaluation, and well data management, together with superior graphics, and robust data integration. Geolog can be used for any number of applications, from log drafting to high-end petrophysics. Its modular design provides a flexible software environment that can be scaled from a single user on a laptop to a team collaborating over the network, customized to specific user requirements.

New Features:

- Geolog 7 adds new technical features, expanded platform and data capabilities, and a convenient and powerful user interface. Other new features:
- New data import, export and preview capabilities.
- Advanced analytics, full documentation and comprehensive audit trail features.
- New ergonomics, including drag-and-drop functionality, simple right mouse button access to all capabilities and more.
- Robust new interactive core analysis and saturation height modelling as an add-on option.
- The industry's only model-based Monte Carlo uncertainty analysis module.

SKUA

The Paradigm SKUA subsurface modelling software suite enables users to create, edit and validate 3D structural, velocity and reservoir models. The technology embeds a native, fully-3D, chronostratigraphic description of the faulted volumes, achieved using the UVT Transform®. SKUA performs fine-scale seismic-based stratigraphic modelling to capture depositional heterogeneities. Modules include velocity modelling, time-to-depth conversion, structure and stratigraphic modelling, seismic interpretation, geological interpretation, 2D/3D restoration, fault seal analysis, reservoir modelling, pre- and post-processing simulation, and well planning.

Geosteer

Paradigm provides advanced well planning and geosteering solutions for monitoring and re-planning wellpaths in real time. The Paradigm geosteer module, added to the Geolog log management, correlation and petrophysics solution, enables the geosteering expert to effectively edit and interpret logs in highly deviated wells, and model the logging while drilling (LWD) tool response, independently of the LWD supplier. Geosteer is performed within the familiar Geolog user interface, and runs on Windows and Linux platforms.

SeisWare™
Industrial Strength Interpretation

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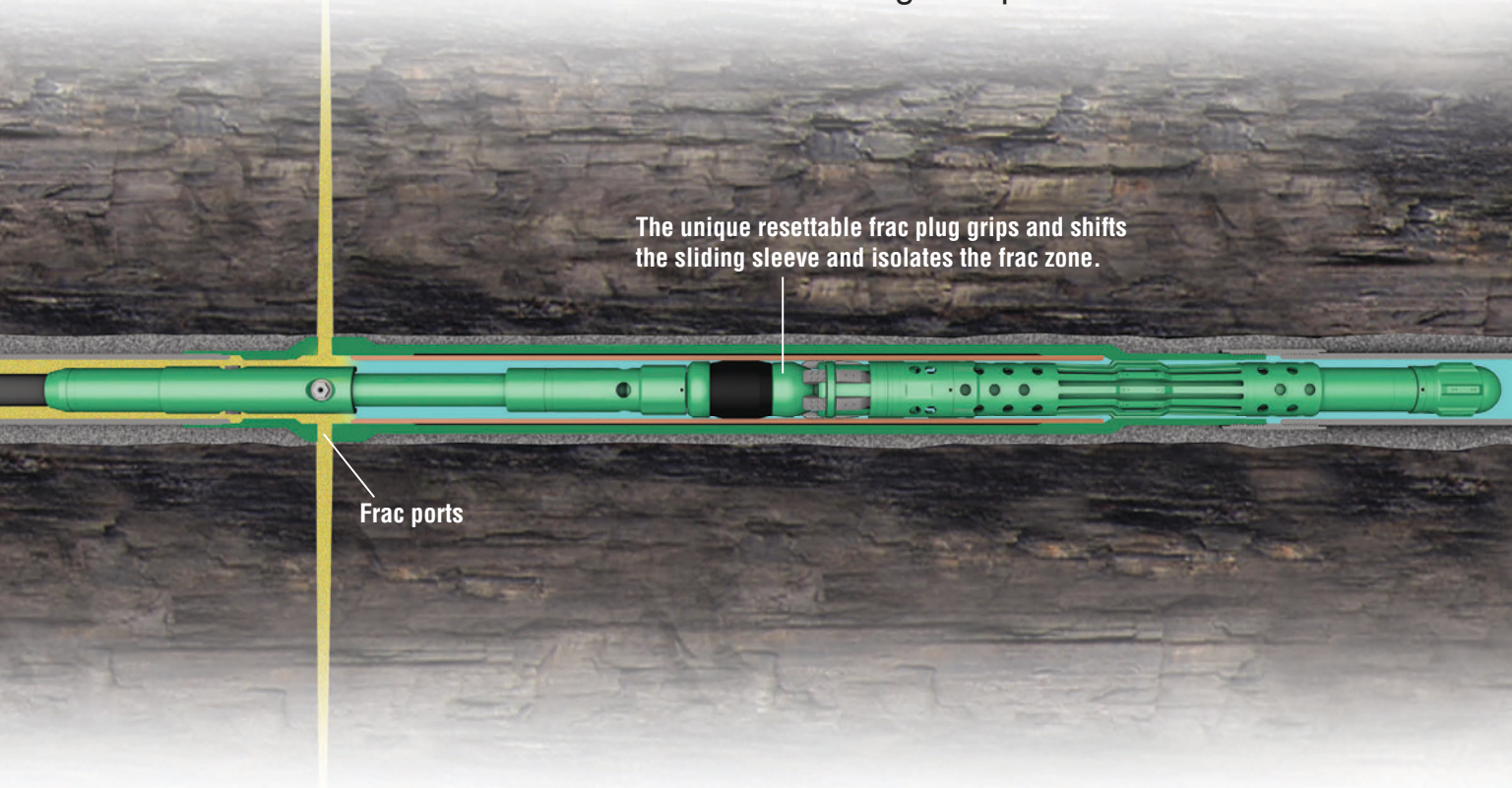
SeisWare

SeisWare International Inc. develops, markets and supports SeisWare seismic interpretation software to exploration and production companies and consultants worldwide. SeisWare is a comprehensive 2D/3D package, and it is the leading interpretation tool in the Canadian market used by geoscientists at large multinational oil and gas companies, as well as the majority of intermediates, juniors and independents.

- **New Features in SeisWare 8.0**
  SeisWare 8.0, released March 2013, included a number of new features and enhancements:
- 41 Rock Solid Attributes have been integrated into SeisWare at no extra cost
- 3D Visualization – Co-rendering and RGBA display options with fault reassignment
- Seven new seismic zone attributes
- Time to Depth – use of k compaction and velocity cube creation
- Data caching for increased network performance
- Keyword analyzer
- New Coordinate Conversion Utility
- Much more…

Fracceleration!

Resettable frac isolation on coiled tubing + Grip/Shift™ sleeves



Plug-and-perf and ball-actuated sleeves are brute force frac methods that bullhead fluids and sand down the casing with no feedback about formation response, no recourse in the event of a screen-out, and no way to manage water and chemicals usage. Both methods limit the number of stages and usually require post-completion drill-out of composite plugs or ball seats.

The Multistage Unlimited system overcomes those limitations and drawbacks using coiled tubing as a work string and circulation path to the frac zone.

Fast frac isolation, mechanical sleeve shift

The work string operates the Multistage Unlimited resettable frac plug, a dual-function tool that 1) isolates frac zones and 2) grips and shifts the sleeves. With no pump-down plugs and sleeve-shifting balls, time between fracs is only about 5 minutes. Large-volume, high-rate fracs are pumped down the coiled tubing/casing annulus; smaller, low-rate fracs can be pumped through the coiled tubing.

Circulation path adds capabilities

The circulation capability allows operators to:

- monitor actual frac-zone pressure for better control of sand placement
- reduce water and chemicals requirements up to 50%
- recover quickly from screenouts by circulating excess sand out of the well
- use sand-jet perforating to add stages in blank casing, without tripping out of the hole

It all adds up to unlimited stages and spacing, streamlined frac operations, better frac control, lower-cost completions, less environmental impact, and no drillouts. Call, email, or visit our website for more information.

MULTISTAGE UNLIMITED™

Leave nothing behind.

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NCS oilfield services

Drilling

Past advances in drilling have often come in the form of faster bits, smarter rigs and improved downhole accuracy. Pad drilling—involving dozens of wells branching out from a single wellsite location—makes use of all these advances, while creating a significantly smaller footprint and a dramatic rise in efficiency. Combined, they have helped lead a revival in oil and gas production across the continent.

The Pad Revolution

Multiple horizontal wells from a single location increasingly the norm

Carter Haydu

▲ COMING OF AGE

Ensign Energy Services' Rig 138 undertakes pad drilling operations in Colorado. A technology under development since the 1980s, pad drilling has evolved from marginal use to the mainstream in recent years.

It seems so simple: drilling multiple wells from one pad is less obtrusive on the landscape, more economical for producers and a major reason for the continued success of the rapidly evolving modern oilpatch—and that's unlikely to discontinue anytime soon.

"There will be increasing circumstances where pads make more sense, just because it's better for the environment, it's better for the supply chain and it's better for efficiencies," says Mark Salkeld, Petroleum Services Association of Canada (PSAC) president and chief executive officer, who suggests over 70 per cent of current drilling licences are for pad-centred horizontal wells.

"It will continue to become the norm, and I can say that with confidence."

Salkeld refers to pre-pad drilling as "the fast and furious sort of thing," with super single, automatic drilling rigs built to move quickly and rig-out fast.

"It used to be in the western Canadian oilpatch that you'd punch as many holes as possible as fast as you can, and we would see 20,000–25,000 wells in a year." Now, thanks to the pads, "we're building multi-well pads for year-round [operations]."

While Salkeld says recent innovations in hydraulic directional drilling deserve much of the credit for increasing pad potential, Robert Geddes, Ensign Energy Services Inc. president and chief operating officer, points out that his company was one of the first to develop onshore pad drilling in Canada over 25 years ago, putting together a "self-moving pad" that did not require a truck to relocate it from one well to the next.

"So it would literally hydraulic-walk itself over. It would go up, out, down and walk itself over to the next location, which would be roughly five metres away. It would then just start drilling again."

Salkeld says the rig-moving system is one notable technological aspect specific to multi-well pad drilling that is not a common feature of conventional drilling rigs, and it is a major reason a pad rig is so effective. "You can move a whole rig—like all the mud tanks, the drill pipe and the derrick, and the whole nine yards," he says, adding that some traditional rigs simply cannot be retrofitted to handle such hydraulic moves.

According to Salkeld, in the "olden days," if there were 16 wells in an area, that would require roads and land disruption to 16 different locations. By comparison, a contemporary pad can be built with two rows of eight wells sprawling out from a central position. With this centralization, Salkeld says, comes the need for more underground infrastructure as companies horizontally drill wells to access material farther away from the source compared to vertically drilled wells.

"So these rigs have to handle a lot more weight."

Geddes says Ensign Energy carries pad rigs varying in power and size, from 800 to

PHOTO: KURT BROWN

2,000 horsepower, selected on the basis of total vertical depth of a zone, as well as how far a well must be drilled horizontally. He notes pad drilling requires a thorough understanding of the reservoir drilled, and anti-collision technology is important in ensuring such underground operations run smoothly.

AVOIDING COLLISION

"We've taken on projects like THUMS Islands off Los Angeles [four artificial islands built by a consortium of oil companies in the 1960s to access the East Wilmington oilfield], where there are probably 5,000 wellbores that have been drilled over the last 30 years. Some of the location techniques in the past may have been suspicious, so anti-collision is important. It's undesirable to run into other wellbores, of course.

"But with the technologies today, we can understand placement of a wellbore to within a few feet."

Scientific Drilling International's Anthony Seredynski, Canadian business development, says his company offers gyro measurement-while-drilling (MWD) technologies that allow for "tight-space kickoffs and mitigate the magnetic interference associated with closely spaced casing." Further, his company also employs anti-collision planning services with a drilling team marking and verifying critical spots along a new well path.

"All wells on a proposed pad, and all wells in the area, must be planned for anti-collision purposes. Any well that closes in, or drills past another well, must be monitored and planned for collision management."

Seredynski notes that his company offers high-speed positive mud pulse MWD tools and electromagnetic MWD tools for surveying while drilling. "Having a powerful enough rig, the right mud, good hole cleaning and proper string design, etc., all play major parts in delivering a long-reach well."

According to Geddes, other up-and-coming technologies for pad drilling include larger mud pumps to run larger motors down the hole, which also requires larger electric drives.

"We're really past the point of driving these rigs mechanically," he says, adding the ability for top drives and drawworks in the mud pump to interact and prescribe tool face setting is a substantial component of new pad technologies currently under development.

With increased complexities associated with modern pad drilling operations, Geddes says companies require large numbers of highly skilled staff to stay current within the industry, separating "mom-and-pop" operations from companies with greater resources.

"You need electronics, engineers and process-control engineers. We're developing algorithms in certain areas, and these algorithms need to be tested and redeveloped, and in some areas you need 30 or 40 different algorithms. This is the development of, of course, building a wellbore for our customer for less cost—more accurate, less cost."

Salkeld says PSAC members are becoming leaders in developing the downhole tools necessary for horizontal pad drilling. From gyroscopes to global positioning system devices to microseismic mapping, service companies are increasingly the ones cultivating technologies offering real-time data from the well, which is important with horizontal drilling, he says.

"Our member companies have tools that position that drill bit in that production string in the perfect location in that formation. Those formations are not perfectly flat, horizontal 500 metres of thickness. They're wavy just like the surface of the earth, and we drill those little hills and valleys 1,000 metres underground to perfect precision."

Salkeld says, "The technology is absolutely amazing" with precision drilling controlled remotely from control rooms in Calgary, mapping the progress of the drill bit as it moves beneath the ground.

All the communication and electrical lines between the power-generation unit to the back end of the rig, as well as the substructure moving area, are also technologies particular to a pad rig, Geddes says, adding that it is ideal to construct rigs specifically for pad drilling rather than simply upgrade conventional rigs to perform the task.

STARTING FROM SCRATCH

"The purpose-built rig is designed for its purpose. When you retrofit the rigs, it's sometimes like remodelling a house—there's a point where when you start from scratch, you end up with a much better product with all the newest technology. All of our pad rigs are [alternate-current variable-frequency drive] rigs, and all of our pad rigs have top drives and interactive controls with basically a joystick-type control kind of drilling."

He says Ensign Energy's pad drilling rigs include instrument relationships, tool-phase oscillation of the top drive, as well as a technology understanding the amount of weight and torque required to maximize penetration rates. "Basically, we're drilling wells with specific-built machinery a lot faster than we've ever done it before."

The substructure of a pad rig is unique, Geddes says, requiring different technological considerations compared to a more conventional rig.

"The catwalk is usually constructed to allow the wellbores that have been drilled to exit out underneath the catwalk. We have an umbilical system that transfers all the fluids from the wellbore back to the mud system to be cleaned and reciprocated through the mud system back to the substructure and back down the hole." ▶

▲ SHRINKING FOOTPRINT
Akita Drilling Ltd. rig and associated equipment on a pad drilling location. Contemporary pad drilling units can drill dozens of wells from a single central location, disturbing just a fraction of the land area that would have been used with traditional single-well drilling locations.

Seredynski says pad rig configurations are typically umbilical—whereby the entire package moves together.

"This enables the wells on the pad to be batch-drilled in a factory-type assembly line system, thus creating efficiencies and saving on standby costs by drilling each section of the well with only the services needed."

Pad drilling requires its own technologies completely separate from single well operations, Salkeld says, not just in regard to the rig-moving systems, but also water containment. "Now that you have the potential to build 16 wells, you're getting companies developing portable fluid tanks, so we don't have to dig holes in the ground and line dugouts.

"Now there are portable outfits coming in, and they're like massive swimming pools: they're lined and they're safe and they're double-walled, they can hold all the fluids. And they're quick and efficient technologies with respect to being able to put these together very quickly and then take them apart and move them to another location."

While the technology for pad drilling has improved substantially over the past decade, Salkeld says there are still efforts to improve and innovate even further. In the northern muskeg regions, for example, he says companies are developing pads that allow drilling of the wells, while at the same time creating the least amount of damage to the surrounding ecosystem.

"There are lots of technologies getting developed to help improve that and make a good, solid foundation, and when spring breakup comes the wells can stay permanent and the land around it can go back to nature."

Speaking during the Hart Energy and Canadian Society for Unconventional Resources 2013 DUG Canada conference and exhibition in February, Mike Wood, Talisman Energy Inc. vice-president, Canada shale division, said his company finds pad drilling is very cost-effective when producing Montney properties. "We do save a lot of money in infrastructure, and then we also drill these in sort of a systematic fashion."

Using microseismic technology to determine the spacing between laterals, as well as how many laterals could be drilled in a pad operation, Wood said, a 24-well pad is typical of what Talisman operations might look like. He said the pad is drilled in "pods," with approximately four wells per pod.

"We do one pod on a pad, we'll get off, and then we'll come back probably in one or two years and drill another pod. The reason is we like to get data in the different layers and then decide which layers we want to target when we come back and drill the remaining pods."

The only limit Salkeld sees to the number of wells that could be drilled on a pad is the formation into which those wells are drilling.

"You might get a formation that couldn't stand having 16 wells producing off it and it makes sense to have only eight wells. But you might also be into a formation—a prolific formation—where it might make sense to have 36 or 40 wells. It just depends on the logistics and the land."

TRIPLE-DIGIT WELL PADS

According to Geddes, the upward limit to how many wells one can fit on a pad can be, in some circumstances, substantial. His company has placed upwards of 100 wells on a single pad.

"That was pretty exceptional. It's a function of how deep you are in the zone, how much land you own, the production rate and how far you are able to get out horizontally, which is what we call an aspect ratio."

While there are the odd "exceptional" pads with triple-digit wells, Geddes says it's far more common to find about four wells on a pad.

Geddes says there is no real downside to pad drilling, and any technological challenges associated with the process are being refined. However, he notes, the conventional method of drilling a vertical well is likely not going to disappear any time soon, either. In fact, he says, single vertical wells are often a key component in enabling horizontal multi-well pad drilling.

"The conventional method, of course, is required to go in and sometimes describe the boundaries of a reservoir economically. You're not going to go drill a horizontal well if you don't know where the reservoir is. You'll drill a vertical well to establish the thickness of the reservoir and the quality of the rock. That's kind of like your recognizance that builds the opportunity for pad drilling into the future."

While pads will take over where they are economical in doing so, Salkeld also says there will still be a role for conventional single well operations, although pad drilling is increasingly becoming the industry norm. "They're becoming more and more popular for a whole raft of reasons." ■

PHOTO: AKITA DRILLING

Improving Drilling Efficiency

Wealth of well data made useful to producers, explorers

It isn't every day that an executive with a software company focused on the oil and gas drilling sector calls a main offering from his company "a concept, not a product," but then that pretty well describes the drilling information databases built by Calgary-based XI Technologies Inc.

That doesn't mean Andy Newsome, vice-president of drilling services for XI, is shy about what TourXchange (pronounced tower exchange), one of his company's lead technologies, can do for those drilling in the Western Canadian Sedimentary Basin (WCSB).

"It's revolutionary," he says.

The privately owned company is the result of a merger in 2004 of Touch Tone Data Inc. and Westcan Petroleum Assets Ltd.

Focused on asset management and drilling and completion programs, the company claims to have "set the industry standard" in providing software tools to help companies make acquisition and divestiture decisions, deal with regulatory and licensing matters, do drilling benchmarking and performance analysis, and conduct well planning and offset research.

Newsome, the son of one of the company's founders who has now retired, was among the company's managers who marked what it called a "milestone" in early April, when it invited drilling professionals throughout the industry to attend the TourXchange Breakthrough Event, held in Calgary. That event commemorated XI having developed a drilling information database for 100,000 wells drilled in the WCSB, a database it began building in 2007.

"This milestone means we now have the digital drilling data for about half of all the wells drilled in the WCSB since 2004," Newsome stated in a press release prior to the event. "This information is critical to well planning, performance benchmarking and analysis of wells drilled. While it's all publicly available information, without TourXchange, that data can only be accessed in hard copy. It requires a lot of effort to find, and even more effort to analyze."

That publicly available information he mentioned in the press release comes from the Alberta Energy Regulator (previously the Energy Resources Conservation Board) and similar regulatory bodies in the other western provinces. The good news is it's readily available to any drilling engineer who wants it. The bad news is, before TourXchange came along, it could be many days—and even weeks—until they would obtain it and make real sense of that information.

▲ SIMPLIFYING THE DATA
XI Technologies' Offset Analyst, released in July, uses the rich data compiled as an outgrowth of the company's existing TourXchange.

"There's a gold mine of information, but if I'm a drilling engineer, the time and effort required to utilize the resource is too high," says Newsome. "I have to arrange to have the drilling reports sent to me, receive it as a PDF, and then I have to take that information and massage it."

That massaging can take a great deal of time if a company is drilling several wells—and oil and gas companies cannot afford to spend more time planning for a drilling project than is absolutely necessary. So the 25-employee company took that information and repackaged it into a format that is easy to access and manipulate.

"Every operator can improve their drilling efficiency," says Newsome. "Access to this amount of data can present opportunities that can result in millions of dollars of cost savings. In exploratory areas where experience is limited, access to historical data is crucial to drilling research."

Current TourXchange members include 15 of western Canada's 20 largest oil and gas producers, and XI continuously adds more members and well data, says Newsome. He says access to the database is "an obvious asset" for both smaller and larger operators.

Newsome says access to the tool allows them to skip some tasks that might take operators a week or longer, condensing it to a day. When researching drilling projects, companies normally need to:

- Decide which wells to research;
- Request tour reports (well data from agencies in PDF form);
- Wait for those reports to arrive;
- Re-enter the data into an analyzable format; and
- Summarize the data in a way that allows them to make their decisions. ▶

PHOTO: XI TECHNOLOGIES

Thanks to TourXchange, members can often skip steps two through five. The data is available ranging back to 1999, mostly because information stemming from further than that loses its relevance.

Operators can see the entire story of a well in a few clicks, including bit records, mud records, time-log summary and a drill curve complete with formation tops, bit changes, mud densities and deviation surveys. It not only provides the specifics of how a nearby well was drilled, but also shows operators how to optimize drill performance. An embedded time-log summary will help operators shave hours or days off of future wells.

The company charges for the service based on a sliding scale.

As an information provider for the industry, XI has a suite of other product offerings ranging from acquisition and divestiture research to research tools for regulatory compliance, to drill performance analysis.

Newsome says the company's most exciting new product, Offset Analyst, released in July after a month of beta testing with early-adopter clients, was made possible by the rich data compiled as an outgrowth of TourXchange.

"It's the second phase of our TourXchange development. The industry told us drilling-problems information was critical, and this product includes a significant drilling-problems information upgrade," he says. During the beta period, the Offset Analyst was put to the test in a live scenario that ended up saving $75,000–$80,000 on a drilling operation.

That product, and others in the future that will flow from the rich data sources XI has developed (which involved the investment of hundreds of thousands of dollars to create a "critical mass" of information), will create opportunities for western Canadian operators to continuously improve their productivity, he says.

Melanie Asuchak, drilling engineering technician with ConocoPhillips Canada Resources Corp., is a strong supporter of XI's TourXchange technology. "I work with XI a lot," she says. "We acquire a lot of our reports through XI. I use it for drilling locator reports, and I use them extensively for offsets. My experience with them has been awesome."

She says access to the data is "simple" and time-saving. "I send my contact an email, telling him what I want, and I get the data within the same day."

Asuchak says the technology is especially helpful when ConocoPhillips is "shifting assets," such as when it decides to spud a well earlier than was originally planned. She says she's "very excited" about the new Offset Analyst offering. "It will save me time, and anyone in this business knows time is money," she says.

Jim Bentein

Smarter Drilling

Going greener with intelligent fluid-management system

With the spotlight glaring on the oil and gas industry's environmental performance as much as it ever has, all sectors of the industry are focusing on greening their operations. At the same time, keeping operations efficient and cost-effective is also vital.

In the service sector, Calgary-based BOE Energy Systems has been doing its part to combine these ingredients; the company is an innovator and leader in dewatering and wellsite fluid-management systems.

Its SmartSite fluid-management system is an evolution of a couple of concepts that Don Smith, president and chief executive officer, developed at his prior company, BOS Rentals Ltd.

In the oil and gas industry, there are two types of drilling fluids used to drill wells: water- and oil-based fluids. Smith notes that in western Canada through the 1980s and 1990s there was a shift away from sump technology and a move into closed-loop or above-ground, pit-type drilling applications. "The technology really wasn't that efficient," he says. "We went through several different methods for disposal of the fluids."

During this same period, drilling rigs went through an evolution, but nobody was examining the fluid-management side, so the manner in which companies managed their drilling fluids remained static, which led to inefficiencies, he says.

"Drilling methods continued to evolve with more horizontal drilling replacing conventional vertical wells, and we began to migrate into more invert-based drilling applications in the latter part of the last decade," Smith notes. "There was a need for more efficient methods of capturing drilling fluids."

With a majority of horizontal wells being drilled using invert-based drilling fluid, improved fluid-management practices with increased environmental consciousness is a necessity.

"There's a need for an improved system, something that had the ability to manage the water-based phase, flip over to the oil-based phase and being able to go back to [the] water-based phase," he adds.

At the heart of BOE's business is its proprietary and patented SmartSite system, which the company says is the most sophisticated fluid-management system of its kind in the world. It includes a state-of-the-art control room and variable frequency drive recirculation system. "Managed on site in a safe, climate-controlled environment, the system allows significant operational, efficiency and safety benefits," Smith says.

The technology allows for more accurate control of the fluid density during drilling, allowing the operator to drill faster. This not only saves considerable time and drilling costs, but also means the wellsite will operate faster.

Smith began his career 30 years ago, working as a roughneck. He moved to a field supervisor position for a small independent oil and gas company before launching his career as an independent drilling and completions consultant.

LIQUID ASSETS

BOE Energy Systems, which depicts vintage Second World War artwork on its equipment, brings fluid-management systems up to date with modern drilling techniques.

In 2001, he formed his first service company, BOS. Smith developed the company's entire product line and was successful in registering four individual patents on various product-line ideas. BOS was sold in 2010 for $110 million.

Having already designed an integrated fluid-management system for water-based applications, he was seeking to adapt it to the new, evolving world of drilling.

Environmental benefits of the SmartSite system include a reduction in water usage of up to 70 per cent, the elimination of reserve pits, more oil recovered and less waste is transferred to landfills, the company says.

Based on experience gained from the past year of field operations, the second-generation units now under construction will feature even greater throughput capability and improved automation features.

The throughput capacity of the SmartSite system means it can handle the high demands of modern drilling techniques. "The fastest sustained drilling rates that I've ever witnessed in my career were about 45 metres an hour," Smith says. "We designed for three times that. The limiting factor of our process capacity is the centrifuge that is processing the slurry mixture that we feed into it.

"At 45 metres an hour, if I design [my system] for 150 metres an hour, I've got more than enough surplus capacity to handle it," he notes. "We're going to look at what's happening and we're going to continue to make sure we're at the front edge.

"We have been extremely pleased with our systems' ability to ramp up throughput to match the drilling rig's [rate of production]. Another distinct advantage of the SmartSite RCT recovery system is the ability to unclog the unit when throughput capacity is exceeded," Smith says. "With the equipment I designed for BOS, the predecessor system to the SmartSite design, if the recovery system plugged, it meant hours of manual labour to unplug and bypassing the unit and losing valuable recovery during the unplugging operation. Our SmartSite RCT recovery unit can be unplugged in a few minutes and it is done automatically with the unit itself."

PHOTO: BOE ENERGY SYSTEMS

> *The fastest sustained drilling rates that I've ever witnessed in my career were about 45 metres an hour. We designed for three times that.*
>
> — Don Smith, president and chief executive officer, BOE Energy Systems

He adds that the company has been working with a major oil and gas producer in the Brazeau area of central Alberta using the SmartSite system. The operator recaptured about 43 cubic metres of oil over the course of the well. This resulted in a "cost recapture" of about $52,000 in oil that the SmartSite system saved from going to the landfill. When compared to a conventional dual centrifuge system without oil recapture, the net saving to the operator was in excess of $38,000 all-in.

Richard Macedo

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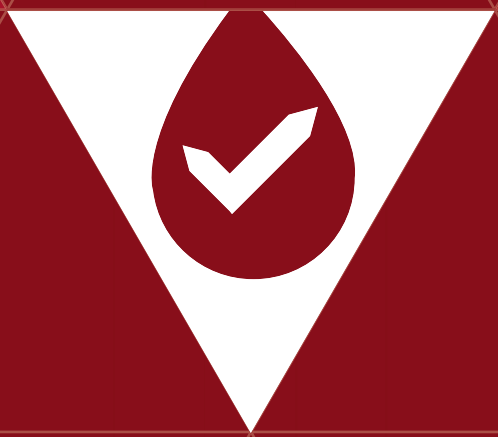


Rising North American oil and gas production has become the story of the year, with experts predicting future energy self-sufficiency is within the continent's grasp. Both conventional and unconventional production is on the rise, thanks to a variety of technological advancements that incrementally have created a transformational outcome. As groundbreaking new technologies continue to open up new sources of oil and gas, it's a trend sure to continue.

Dispensing With Diluent

Private firm pursuing plan to upgrade SAGD bitumen at wellhead

By Pat Roche

◀ PARTIAL UPGRADING
Too viscous to flow through a pipeline as produced, bitumen must be either upgraded or diluted with lighter hydrocarbons for shipment. Value Creation proposes to produce a pipelineable medium-grade crude in the field.

Alberta's shippers of diluted bitumen began 2013 in an unenviable position. They were only getting about $60 per barrel for their product, but natural gas condensate—which raw bitumen is blended with so it will flow through pipelines—roughly tracks the price of light crude, which was about $90 per barrel. So to ship their bitumen to market, producers had to buy a product costing roughly 50 per cent more.

It takes roughly half of a barrel of condensate to pipeline a barrel of bitumen. (As a general rule of thumb, half a barrel of condensate is blended with one barrel of pure bitumen; hence, the condensate is roughly one-third of the diluted bitumen.) Given the often-wide gap between the price of what's being bought and what's being sold, this is hardly a desirable situation for the bitumen seller.

And the condensate-to-bitumen price ratio is just one of the factors affecting the economics of shipping diluted bitumen to market. A dedicated condensate delivery pipeline has to be built, and a bitumen sales pipeline has to be 50 per cent larger than the volume of bitumen shipped because one-third of its capacity will be filled by diluent.

The ideal solution would be to upgrade the semi-solid bitumen to a pipelineable viscosity at the wellsite, thereby eliminating the cost of buying condensate, the cost of building and operating a condensate delivery pipeline, and the cost of making sales pipelines 50 per cent larger than the actual amount of bitumen to be shipped.

This has never been achieved commercially, but a Calgary entrepreneur and veteran of the refining/upgrading industry believes he can do it. For the last few years, Columba Yeung, founder, chairman and chief executive officer of privately held Value Creation Group, has been quietly working to commercialize a technology to upgrade bitumen directly from the wellhead.

(Other companies with partial-upgrading processes include Ivanhoe Energy Inc., Honeywell International Inc. and MEG Energy Corp. Ivanhoe's technology was featured in *New Technology Magazine* in 2007, and Honeywell's UOP process was covered in the December 2012 issue. MEG's partial-upgrading technology was covered in the March 2013 issue of the magazine.)

Yeung, who holds a PhD in chemical engineering from the University of Toronto, says he played a key role in the design of Royal Dutch Shell plc's Scotford refining and bitumen-upgrading complex near Edmonton while working for Shell's Canadian subsidiary.

Last decade, he embarked on an ambitious plan to build an independent upgrader in the Industrial Heartland area northeast of Edmonton. The first phase of the so-called merchant upgrader was designed to process 77,500 barrels per day of diluted bitumen.

The project was to be financed by debt and equity. With substantial equity raised, major vessels were ordered and delivered and construction of the plant was well underway before the debt financing was completed. "We were so successful in raising equity, I guess success went to our heads," Yeung concedes wryly.

Before Yeung had negotiated any feedstock contracts with bitumen producers,

PHOTO: VALUE CREATION GROUP

the global financial crash hit in September 2008. In the debt meltdown that followed, it was virtually impossible for major projects to get credit. Major Alberta oilsands projects were deferred or cancelled, and Yeung's Heartland upgrader project obtained court-imposed protection from creditors.

Not long afterward, the project came out of creditor protection via a joint-venture deal with BP p.l.c. that resolved Value Creation's financial challenges. In exchange, BP got 75 per cent working interest in Value Creation's Terre de Grace leases north of Fort McMurray. Yeung says plans for a steam assisted gravity drainage (SAGD) project on those lands are proceeding with BP as operator.

Meanwhile, industry interest in upgrading in Alberta waned. The rationale for upgrading bitumen to synthetic crude oil was that bitumen fetched a much lower price than light crude. But as Alberta bitumen producers started getting pipeline access to the key U.S. oil distribution hub at Cushing, Okla., the heavy oil differential—the gap between the price of heavy and light oil—narrowed so much that many questioned the wisdom of upgrading.

That trend reversed itself with a vengeance in late 2012. The gap between the price of Western Canadian Select (Alberta's heavy crude benchmark) and U.S. light oil benchmark West Texas Intermediate ballooned to $40 per barrel—a spread not seen in about five years. This was due to a pipeline glut caused by soaring production from the Alberta oilsands and from tight-oil formations in the United States.

With bitumen sellers squeezed between low bitumen prices and the high price of condensate needed to dilute it, Yeung says interest in his planned merchant upgrader has been rekindled. However, having been burned once, he doesn't plan to resume construction until all the financing is in place.

UPGRADING AT THE WELLHEAD

So while the merchant upgrader project is far from dead, Yeung is moving ahead with a much more intriguing idea. Unrelated to the lands it holds with BP, Value Creation has another oilsands property it controls 100 per cent—the TriStar blocks—also in the Athabasca oilsands region of northeastern Alberta.

Last fall, Value Creation applied for regulatory approval to develop a 75,000-barrel-per-day SAGD and primary upgrading project at a site about 10 kilometres northeast of Fort McMurray. The project, called Advanced TriStar, will be built on part of its TriStar lands. The company has also applied for a 1,000-barrel-per-day pilot test on the main TriStar block. Value Creation is seeking approval for two SAGD well pairs and surface facilities, including upgrading infrastructure. The privately held firm won't disclose the capital cost of the pilot, but Yeung says the financing for it is already in place.

◀ SEEING IS BELIEVING
Value Creation's accelerated decontamination prototype plant in High River, Alta., allows potential interest partners and investors to observe the company's upgrading process at work.

Construction of the pilot can start once the project gets regulatory approval, which Yeung hopes will happen this year. If it gets the required approvals, Value Creation plans to have the pilot in operation in the second half of 2014.

Yeung originally planned to use his technology to upgrade mined bitumen with the goal of eliminating tailings ponds. But then he decided he wanted to produce bitumen as well as upgrade it, and in situ bitumen production can be done on a much smaller scale than oilsands mining. So the chemical engineer modified his process for use in SAGD projects. In situ bitumen production will be less challenging than mined bitumen, Yeung says, because the wellbore fluids contain far less water than does the slurry from a mine site.

From a logistical standpoint, a key difference between Yeung's technology and conventional upgrading is that his process is designed to take a SAGD project's bitumen-and-water emulsion directly from the wellhead. In thermal oil production, huge volumes of steam are injected into a reservoir to heat the bitumen so it will flow; much of this water is produced back to the surface with the oil. In a conventional set-up, the bitumen-and-water emulsion from the wellhead is cooled and routed through oil-and-water separation vessels before the bitumen is diluted for pipelining to an upgrader.

Conventional upgrading works at high temperatures and high pressures and produces a light synthetic crude oil. Value Creation's process, on the other hand, is designed to work at close to wellhead temperatures. This means much lower capital and operating costs. For example, the low-intensity process won't need the thick-walled vessels made from special alloys that are required in conventional upgraders that run at temperatures of 400–560 degrees Celsius. Yeung won't disclose the exact operating temperature of his process, but says it will be "well below" 200 degrees Celsius.

This has an environmental benefit. "We use the waste heat from the wellhead to achieve a good part of our energy requirements, so the net energy requirement is unusually low," Yeung says. The lower the energy requirement, the lower the fuel consumption and greenhouse gas emissions.

Whereas conventional upgrading uses energy-intensive processes such as coking and hydroprocessing, which require high temperatures and pressures, Value Creation takes out the "heavy ends," or impurities—known in the trade as "nasties"—by making the submicron-size particles bigger until they precipitate out in water.

To put it simply, conventional upgrading removes the oil from the bitumen stream, ▶

PHOTO: VALUE CREATION GROUP

> *We make [synthetic] crude oil so clean, so easy to crack, [that] any of the refineries that could not crack bitumen could crack this cleaned-up oil quite easily.*
>
> — Columba Yeung, founder, chairman and chief executive officer, Value Creation Group

leaving behind a concentration of the difficult components that have to be sent to a brute-force process such as coking. Value Creation's process removes the impurities and sends the crude oil stream to the refinery. Yeung uses a sugar solution as an analogy. "Other people try to remove the water, concentrating into a syrup.... We crystallize the sugar out."

The impurities, or asphaltenes, are suspended as extremely fine particles in the bitumen. Value Creation's process makes those particles grow at the oil/water interface. When the particles get big enough, they precipitate into a water slurry from which they are extracted as a powder.

"We make [synthetic] crude oil so clean, so easy to crack, [that] any of the refineries that could not crack bitumen could crack this cleaned-up oil quite easily," Yeung says.

MEDIUM-CRUDE MARKET NICHE

Value Creation's upgrading strategy is to avoid duplicating what refineries can do and target an underserved segment of the refining market.

As a chemical engineer who spent much of his career in the downstream sector, Yeung is strongly focused on markets. Production from Alberta's oilsands regions is either sold as diluted bitumen, which goes to refineries that can process very heavy oil, or upgraded to synthetic crude, which goes to refineries that process light oil.

"Our industry...targets the two ends of the refinery spectrum—the light and the very heavy," says Yeung. "Most of the refineries actually process medium crude." Why? Because refineries were built for the crudes that were available—such as Arab Light, Arab Medium and Alaskan crudes, which are all typical medium crudes.

While most of the Alberta oilsands industry is selling crudes that fit the extreme ends of the refining spectrum, Value Creation will target the much larger percentage of refineries that prefer medium crudes. The company's strategies are to greatly reduce the viscosity to produce a crude that can be pipelined without diluent, and also to remove most of the asphaltenes, producing a crude that's very easy to crack so most refineries can handle it.

The advantage of these strategies is the crude oil seller wouldn't be dependent on a relatively small number of refineries and pipelines.

Heavy oil conversion capacity is available at Texas refineries because of declining production of Venezuelan and Mexican heavy oil. That capacity is now available to Alberta bitumen producers, but it means shipping the product thousands of miles. Yeung supports the building of pipelines to enable Alberta bitumen to reach more markets; he is simply pointing out there are ample medium crude refineries that can be reached today and that are much closer to Alberta's oilsands.

So medium crude would have a market advantage over diluted bitumen. But why not upgrade it all the way? Why settle for medium crude when you could produce a light synthetic crude? The problem with marketing conventional synthetic crudes, Yeung says, is that a relatively small number of refineries require crude oil with no residue.

Synthetic crude oil has no residue. But Yeung says almost all refineries have vacuum units for distilling residue. As the crude oil goes through the vacuum column, the light oil rises and the heavy residue goes to the bottom. If those refineries switch to feedstock with no residue, then the vacuum units would shut down, idling part of the owners' capital investment.

"It is when you don't duplicate the capital investment and processing [capability] of refineries that you make most of the return—because you fill the gap that they cannot do and allow them to finish the job," Yeung says. "When you [duplicate] the work that the refinery can do, they can't pay you full value because you idle some of their facility. You underutilize their facility."

Yeung won't disclose the actual capital cost of his upgrading process. "But I would say...our capital intensity—capital cost per barrel—[is] less than half of conventional," he says. "And the operating cost—which is even more crucial—is also less than half. How much less than half is a trade secret."

He describes his process as "mechanically, surprisingly simple," but "scientifically, surprisingly complex."

It all sounds too good to be true, and Yeung is well aware of this. So he built a demonstration plant at High River, south of Calgary, where potential interest partners and investors can witness the process firsthand. "Often companies find it unbelievable that you can upgrade the emulsion directly [from the wellhead]. Sometimes they bring their own emulsion from [their own SAGD] plants to make sure," Yeung says.

"Seeing is believing," he says.

WHY UPGRADE IN ALBERTA?

But does it make economic sense to build upgrading capacity in Alberta? For Husky Energy Inc., the answer is a no-brainer. The company once considered doubling the size of its Lloydminster upgrader, but shelved the idea.

At an investment conference in New York City in January, Rob Peabody, Husky's chief operating officer, was asked whether the company might still make such an investment. He said that when Husky last looked at local upgrading, it concluded the cost of building upgrading and refining capacity in the United States was about half as much as in Alberta. "And I don't think that's fundamentally changed," Peabody told analysts.

Husky traded some of its bitumen reserves to BP to get access to the latter's upgrading and refining capacity in the United States. So bitumen from the Calgary-based producer's 60,000-barrel-per-day Sunrise project will be upgraded south of the border.

Yeung says it depends on what you measure. "Alberta does have some disadvantages. One is cold weather. So it's more expensive. The other is that because of the industry growth, [Alberta has] very high labour costs."

The real test of Value Creation's upgrading technology will be in the field. If it really is possible to economically upgrade bitumen by taking the emulsion right off the wellhead and eliminate diluent and associated infrastructure, the cost savings for bitumen producers would be enormous. ■

A Calculated Risk

Cenovus's blowdown boiler process reduces water usage, costs

When Cenovus Energy Inc.'s technical team first proposed running waste water from its steam generators at its Foster Creek oilsands operations through a second boiler without treatment in order to increase the amount of water it was recycling, colleagues promptly organized a pool as to how long it would take before solids in the water plugged the tubes.

The results convinced the skeptics. Over a period of 166 days in 2007, a pilot project using a 50-million-British-thermal-unit-per-hour boiler—smaller than the boilers typically used to generate steam—generated more than 59,000 cubic metres of steam and produced nearly 150,000 barrels of bitumen using only untreated water. Following the pilot, Cenovus ran a successful commercial test for 100 days in late 2010 and early 2011 using a larger, standard 175-million-British-thermal-unit-per-hour boiler.

The boilers were inspected at the end of each testing stage and showed no significant wear, despite the higher component of solids, proving that a boiler could generate steam using untreated waste water, in contrast to standard industry belief.

"We wanted to recycle as much water as we reasonably could and to exceed the regulations, going beyond compliance," says Mark Bilozir, director of technology development at Cenovus. Under the company's patented blowdown boiler process, up to 90 per cent of the original input water can now be converted to steam.

In a typical steam assisted gravity drainage production operation, a steam generator converts about 80 per cent of the water it receives into steam, with the remaining 20 per cent usually disposed of due to the concentration of solids left behind in the water.

"We could take that water out of our normal operations and spend a lot of money and chemicals and equipment and treat it so that it is back down to spec and run it again," Bilozir says. "But it's a lot more economical and simpler if we can just figure out how to go from one boiler right into another, and find out what the problems are and just solve the problems rather than just treating everything."

PHOTO: CENOVUS ENERGY INC.

▲ PUSHING BOUNDARIES
In going off-spec from normal operating procedures, Cenovus was able to prove it could run leftover water through a secondary boiler untreated and significantly boost its recycle rate.

To accomplish that, those involved in the project had to go "off-spec" from what was considered normal boiler operation, something that Bilozir acknowledges caused a lot of debate within the operation. "We took a calculated risk and some people were thinking there is no way this could work, but we had good reason and solid evidence to say we think we could do this," he says.

WATER SAVINGS

A major benefit of the blowdown boiler process is a 50 per cent reduction in the demand for makeup water, which means that the company draws less water from natural saline aquifers, according to Bilozir. As a result, only two to five per cent of the original feed water is disposed of in saltwater aquifers compared with the 20 per cent had the water not been run through the blowdown boiler.

The process also reduces capital and field costs. If Cenovus can get more steam from the same amount of water, fewer water wells will be needed to provide water and less water will have to be disposed of, he says.

"This is about as close as you can get [to a win-win] because we don't add any chemicals or do further treating," he says. "We just get more steam with less energy and less water required from the environment."

The water treatment plant, the largest single capital cost, can be a little smaller, resulting in an estimated savings of $100 million because now it will have to handle less than 10 per cent of the blowdown water compared to the previous 20 per cent. "We sort of joke that we run giant water treatment plants and produce a little bit of oil to pay for it," says Susan Sun, senior staff, water treatment engineer.

Based on the company's evaluation, the Cenovus-patented process will reduce operating costs by 15 cents per barrel, says Sun. For a 100,000-barrel-per-day operation, that would amount to about $15,000 per day. "It can improve the water recycling ratio above 90 per cent without using energy-intensive technologies like other people are using in the industry."

Additional benefits include reductions in natural gas requirements, CO_2 emissions, the waste disposal stream and the surface footprint due to the reduction in the makeup and water disposal systems, as well as the smaller water treatment plant. ▶

"This was tremendous work by Susan and we had a guy who is very well versed—Mike Wasylyk, a long-time boiler guy—[also] behind it," says Bilozir. "There are a lot of good people who did a lot of good work on this.

"Cenovus spends a lot of time making its plant more efficient, using less water and making the whole project smaller any way that it can," he says. "It's a big area of research for us."

The blowdown boiler process will be used in future expansion phases at its Foster Creek and Christina Lake in situ oilsands projects, as well as at future developments at Narrows Lake and Telephone Lake, says Sun. At Foster Creek, one of Phases F, G and H will be run off water from the two other phases, says Bilozir.

The blowdown boiler process could potentially be licensed by other oilsands operators who have shown interest in it. While Cenovus sees its patented process as a competitive advantage, it would be open to discussing the idea of licensing, though "the terms have to be defined," he says.

Elsie Ross

Prints Charming

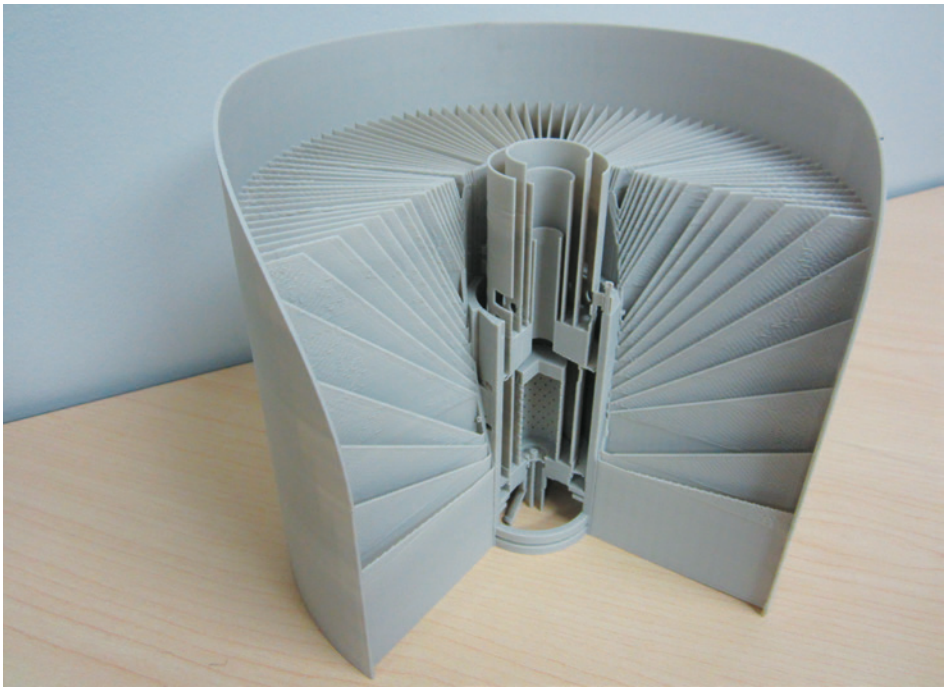
3-D printing is opening a whole new world to R&D in the petroleum sector

At first glance, the cutaway plastic model seems mundane—but appearances can be deceiving. The generator prototype, commissioned by Global Thermoelectric Inc., was created using a 3-D printer, a device that extrudes a thin layer of material to slowly build a complete 3-D object. "The potential of what it can do is limited only by the bounds of your creativity," says Jim Kelsall, product line manager for Global Thermoelectric.

3-D printers, which can range in price from $1,000 to over $500,000, are emerging from their niche as a novelty technology into mainstream manufacturing. "3-D printing is going to be tremendously valuable to the O&G [oil and gas] sector," says Stephen Scott, president of Area 51 Machine Design Inc., a Calgary-based design consultancy. "Let's say you want to design a new downhole tool for hydraulic fracturing. You can spend $250,000 creating a metal prototype of a new design, but with the 3-D printer, we can do a full-scale cutaway prototype in plastic for $1,500."

Area 51 is a coalition of machinists, designers and related technical staff. It has several areas of activity, including 3-D design and computer numerical control (CNC) metal machining. For the last nine years, Area 51 has been designing and aiding in the manufacture of new machinery in a wide variety of industries; their oil and gas clientele include companies that supply top-drive drilling systems, pump drives, gear mechanisms and portable generators.

"When you are designing something new, there is never any clear solution—it is always a balance of compromises," says Scott, a mechanical engineer and machinist. "The value of 3-D design is that you can take an idea, even an unorthodox idea, and do many iterations. This allows you to work out whether it's going to be too heavy, or the ease with which you can take it apart and repair it. It also allows you to work out how it will withstand field abuse and run reliably."



▲ EXACTING REPRODUCTION
A cutaway generator prototype created for Global Thermoelectric by Area 51 Machine Design using its 3-D printer. The printer has enabled Area 51 to significantly cut the time frame to produce component prototypes.

While 3-D design and CNC have been in common use for several decades, 3-D printing is a relatively recent wrinkle. The cutting edge of the technology are printers that can print using metal—the process is called laser sintering—but they are still several years away from being a practical means to create a usable object directly from 3-D design software. Most 3-D printers use acrylonitrile butadiene styrene (ABS) plastic, which has about one-tenth the strength of steel.

Area 51 employs a Stratasys Inc. machine that features a working chamber capable of producing an object as large as six cubic feet. The printer lays down ABS plastic in liquid form at 280 degrees Celsius, which then cools down and solidifies at 80 degrees Celsius. The thickness of each layer can vary from 10/1000 inch down to 5/1000

PHOTO: AREA 51 MACHINE DESIGN INC.

"Let's say you want to design a new downhole tool for hydraulic fracturing. You can spend $250,000 creating a metal prototype of a new design, but with the 3-D printer, we can do a full-scale cutaway prototype in plastic for $1,500."

— Stephen Scott, president, Area 51 Machine Design Inc.

EASY CONCEPTUALIZATION
Realistic visualization of component prototypes is one of the main advantages of 3-D printing, according to Area 51, increasing the chances of client buy-in.

PHOTO: AREA 51 MACHINE DESIGN INC.

inch. Each pass can take more than a minute to complete. The Global Thermoelectric prototype took 37 hours of continuous printing, with over 800 layers.

Creating a plastic prototype has several advantages. "The primary value of 3-D printing is visualization and presentation," says Scott. "Designers work in 2-D and 3-D, and with the proper training can visualize what a prototype will look like and perform just from the representation on the screen. But most clients are business people, and to them a 2-D representation can look like a scribble. And if they can't visualize it, you can't get the buy-in for them to write the cheque. A 3-D model takes away that conceptualization barrier."

Plastic prototypes can also be directly installed in many situations where the strength and durability of steel are not required. Area 51 designed and printed several components of an air compressor for Trido Industries Inc. The Calgary-based company specializes in green technologies for the pipeline sector. During the normal course of operations, pipelines emit small but environmentally significant amounts of natural gas through instrumentation processes on their networks. Trido designed a solar-powered air compressor that replaces natural gas with ambient air, eliminating discharge of methane; the problem was that the compressor was too inefficient. Area 51 redesigned the cylinder heads and remotely activated valves, increasing efficiency to 82 per cent. They then printed the valves in ABS plastic and placed them directly into service.

3-D printing also promises to speed up conventional production of metal parts. The company has worked with several foundries to create core and patterning moulds, explains Scott. "Let's say you want to make a metal vase. The foundry creates a pattern of what the vase will look like on the outside then uses this pattern to create a mould from packed sand. They then create a core mould of the volume of the vase on the inside. They place the two together and pour molten metal into the gap. The sand is then broken up, and the metal vase is ready. The entire process can take 12–16 weeks, and cost from $5,000–$30,000. With 3-D printing, you can create the core and patterning moulds from polyurethane in six days at one-quarter of the price."

Global Thermoelectric benefitted from 3-D design and printing in several ways. Since 1975, the Calgary-based firm has been using technology developed by 3M Canada for NASA's Apollo missions to build portable thermoelectric generators for use where power is unreliable or absent. "Global's products provide power for actuators such as block valves, instrumentation and communications equipment on gas pipelines, wellheads and for a wide variety of other applications," says Kelsall.

Global Thermoelectric's generators are designed to run at lower ambient temperatures typically encountered in North America; however, the company wants to open up new markets in the Middle East and North Africa, where ambient temperatures are much higher.

Release for the sale of the new generator was targeted with a short deadline, which necessitated a design cycle shorter than the company's standard, says Kelsall. "Area 51 can draw upon a different well of experience in design and simulation, and was able to assist us to meet the release deadline. They also possess the ability to provide rapid prototyping services with 3-D printing. We were able to shorten our product design cycle by some three months and rapidly turn concepts into reality, testing multiple concepts that led to the right solution. Traditional prototyping using machined parts would have significantly increased the development cost and timeframe and possibly have us miss the market window."

In the long term, metal laser printing will become far more sophisticated. "Metal is a crystalline lattice, so it is only as strong as its weakest link," says Scott. "There are a lot of things that can go wrong when you are working with metal; you can get an improper mix of alloys, or the formation of cavities. The tensile strength of metal—how strong it is when you stretch it—can be severely weakened by imperfections. When you construct a metal object molecule by molecule, however, you eliminate imperfections and increase tensile strength a hundredfold; an F-14 fighter plane no longer has to weigh 40,000 pounds, it can weigh 5,000 pounds."

■ ***Gordon Cope***

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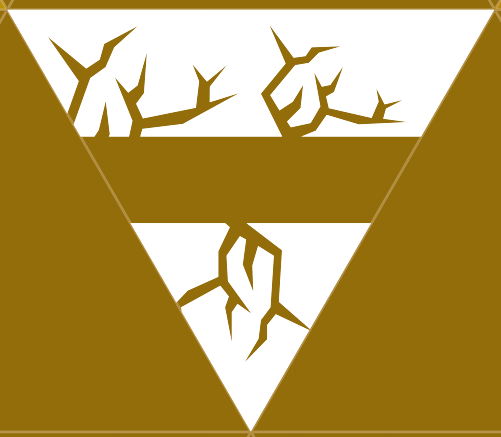

Still a relatively new innovation, multistage fracturing—the advance credited with igniting the shale gas revolution—continues to undergo rapid change and improvement. From better proppants to smarter frac placement and new and better downhole tools, companies are streamlining the process, leading to improved production and lower costs.

Proppant Progress

New players and strategic partnerships, more research and niche products are adding pizzazz to once-obscure sector

By Godfrey Budd

▲ SAND ASCENDANCY
A pile of sand prior to coating. Sand makes up 80–90 per cent of the proppant market, with ceramics and resin-coated proppants splitting the rest.

The proppant sector has been on its double-digit-per-annum growth curve for a while now, and the pace shows little sign of slowing, despite what some see as the risk of a glut in the wake of a swarm of new entrants. With the widespread application of substantial fracturing treatments for shale gas and tight oil completions and, according to some estimates, proppants often accounting for up to five per cent of the cost of a well, this hitherto somewhat-obscure sector could soon acquire some heft within the industry as a whole.

New partnerships, capital infusions for research and more transport infrastructure for moving the growing tonnage of frac sand and other proppants are all part of the mix in this fast-evolving sector.

Northern Frac Proppants LLC (NFP), a self-described "emerging producer of monocrystalline sand [frac sand]," announced on April 2 a multi-year agreement to supply Northern White frac sand to Carbo Ceramics's new processing plant in western Wisconsin. (Some of the most sought-after frac sand is mined in Wisconsin and other northern states.) Houston-based NFP is building a 145-acre sand mine and processing plant adjacent to Carbo's sand-processing and resin-coating plant in Marshfield, Wis. The sand for the Carbo plant, however, will come from an existing NFP operation in Bluff View, Wis.

Also in early April, Santrol, a Fairmount Minerals company, announced the opening of the Santrol Technology Center, near company headquarters in Sugar Land, Texas. It replaces a research and development (R&D) facility in Fresno, Texas. The announcement said the new lab would help it expand its proppant portfolio. Besides "pure research in pursuit of next-generation technology," work there will also include "engineering tougher, environmentally compliant proppants," the company said.

On the infrastructure side, the Oilfield Technology Group of Momentive Specialty Chemicals Inc. announced in February the opening of a new transload facility in Colorado that should be well positioned to serve the Denver-Julesburg and Powder River basins.

Increased infrastructure to support the proppant sector in Canada is also underway. In late March, Claim Post Resources Inc., a mining company, announced that it had acquired 75 per cent of a parcel of leases in the Seymourville silica sands in Manitoba. Explaining its intent to develop the sands to provide proppant for oil and gas, the company noted that a large proportion of frac sand used in Canada is imported from the United States. Sand from Wisconsin is shipped to the Saskatchewan Bakken, and even to the Montney and Horn River in British Columbia.

Frac sand production in the United States has climbed from 13 million tonnes in 2010 to 22 million in 2011, with an estimated 28 million for 2012. Based on its assessment of average depletion rates in fracked oil and gas wells of around 30 per cent per year, Claim Post expects that "the tonnage of frac sand will continue to increase."

In Alberta, Athabasca Minerals Inc. hopes to be producing proppant from its Firebag Frac Sand Project on a 12,800-hectare property about 100 kilometres north of Fort McMurray by sometime in 2014. "We expect to be able to provide 20/40 mesh for plays like the Bakken and Viking," says Dean Stuart,

PHOTO: PREFERRED SANDS

who provides investor relations consulting for Athabasca Minerals.

(Proppant sizes are generally referred to by an API sieve size designation and typically range from eight to 140 mesh, or 106 micrometres to 2.36 millimetres. A proppant with a 20/40 sieve cut would be one in which 90 per cent of the sand falls between those two sizes.)

The location of the company's planned frac facility should make it a fit for supplying other plays in western Canada, including the Duvernay with 70/140 mesh proppant, he says. Frac jobs in the liquids-rich natural gas play can use as much as 2,000–3,000 tonnes per well, compared to 120–240 tonnes per well in oil plays.

LOGISTICAL CHALLENGES

Expansion in the proppant sector is driving the development of tailored logistical solutions. The proprietary Sandbox system from TBM Group of Companies uses modified shipping containers to transport proppant from the outlet facility to the lease, or it can be used for storage. Depending on density, a container holds typically 22–24 tonnes of proppant, says Claude Lavoie, president of TBM. The company also offers the PropMaster, a site storage system from Prop Equipment Systems Inc. whose containers can hold 130 tonnes and are designed specifically for proppant storage at a frac site or lease.

TBM Sand & Storage Logistics, LLC., the arm of TBM that offers the Sandbox and PropMaster, has two transload and storage facilities right now, one in San Antonio, Texas, and the other in Fort Saskatchewan, Alta. The company is scouting to add a couple more, with locations in North Dakota and southern California. Fabrication of TBM's Sandbox units is being done at plants in northern California and Oregon, where costs are lower than in western Canada, Lavoie says.

A logistics specialist with over two decades of experience providing transport and related solutions for the oil and gas industry, Lavoie has applied his expertise to the import and distribution of proppant products from Sichaun FultonTec Co. Ltd. The privately owned Chinese company has been exporting proppant to Canada since 2005 and to the United States since 2002.

FultonTec offers a range of ceramic proppants—from high-strength 20/40 mesh with six per cent crush at 15,000 pounds per square inch (psi) pressure to ultra lightweight 40/80 mesh with seven per cent crush at 10,000 psi. The company also offers two grades of pre-cured resin-coated sand. "We have sand in China, but we're not allowed to export raw sand. But we can export coated sand," says Wilbert Fan, vice-president, international business, at FultonTec.

According to Fan, FultonTec's ultra-light proppant, FTecUltra, has specs that are similar to those of equivalent products from other ceramic proppant manufacturers. "It has at least twice the conductivity and permeability than those of sand-based proppants. It's much lighter than sand, meaning considerable savings on the pumping and frac fluid system. This is cost-effective for slickwater fracturing applications, as low-viscosity slickwater fluids require the use of smaller-diameter and lower-density proppants," he says.

Also, he says, as a chemically inert, sintered ceramic, the ultra-light proppant won't react with frac fluid chemicals, including cross-linkers and breakers.

Sand takes up between 80 and 90 per cent of the market with the remainder roughly split between ceramics and resin-coated proppants.

The downside of ceramics, of course, is their price. They are about four times more expensive than typical sand proppants that simply meet API/ISO specifications and requirements, Lavoie says. At a price point somewhere between the two lies resin-coated sand.

Resin coating strengthens proppant sand by distributing the pressure applied to each grain. It can encapsulate cracked grains of sand so its composition is held together and fewer fines are released into the fracture. Also, resin-coated proppants tend to work better at higher closure pressures than sand that hasn't been coated.

But resin-coated proppants are typically not at their best in low-temperature formations. As a paper presented at the SPE Unconventional Resources Conference in Calgary last fall pointed out, these proppants were originally designed for higher-temperature applications. This made most resin-coated proppants less than ideal for many tight oil plays in western Canada, including the Slave Point, Cardium, Bakken and Viking, where reservoirs typically have relatively low temperatures, as the paper noted.

At about the same time, in the fall 2012 edition of its company newsletter, Momentive announced that its Yukon Black low-temperature proppant was now available. The curable resin-coated proppant comes in 16/30 and 20/40 mesh sizes.

"Incorporating Momentive's newest Stress Bond resin technology, the proppant bonds in the fracture with closure stress, providing increased fracture flow capacity and proppant flow-back control," according to the newsletter. It also says that the new proppant provides "low-temperature bonding down to 21 degrees Celsius (70 degrees Fahrenheit) bottomhole static temperature without the use of a low-temperature consolidation aid."

Another Momentive proppant first introduced to the U.S. market in 2011 is called OilPlus. It is a curable resin-coated proppant geared for fracking in oil- and liquids-rich reservoirs.

With uncoated frac sand, water adheres to its surface, says the company. Since the water is not fully displaced, the space between the proppants is blocked and the flow of oil is reduced. OilPlus's optimized resin system prevents water and oil from bonding to its surface, increasing the permeability to oil in the proppant pack and boosting production.

"Laboratory tests showed that OilPlus proppant demonstrated 283 per cent more oil flow through the proppant pack than conventional proppant," according to the company newsletter. The company now manufactures OilPlus proppant at ▶

> *Our coating has no phenol or formaldehyde. The chemistry involves polyurethane technology. It's environmentally friendly to make. Pearl's strong coating is non-toxic.*
>
> — Bob McDaniel, vice-president, technology, Preferred Sands, LLC

▲ FAST BONDING
A consolidated plug of a low-temperature product Preferred Sands calls Garnet. Unlike most resin-coated sand proppants, Garnet does not require an additive for the phenolic coating to bond in lower-temperature formations.

its plant in Sturgeon County, Alta., and operates six transload facilities throughout western Canada.

Resin-coated sands, which rely on phenolic chemistry, were first used in the foundry industry for moulds. Salespeople looking to sell more product sought other markets, and a fit was found with the fracking sector, as coated sands enabled proppant to stay in a fracture because of their adhesive properties, says Bob McDaniel, vice-president of technology at Preferred Sands, LLC.

ENVIRONMENTALLY FRIENDLY

One of the drawbacks to phenolic-based resin coatings is that phenols and formaldehyde can leach out. As part of its mission to provide effective, environmentally safe products, Preferred Sands has introduced RCS Pearl as an economic alternative to costly resin-coated and ceramic proppants, McDaniel says. (RCS stands for resin-coated sands.)

"Our coating has no phenol or formaldehyde. The chemistry involves polyurethane technology. It's environmentally friendly to make. Pearl's strong coating is non-toxic. It has a unique set of properties for hot, high-pressure applications, typically 200–350 degrees Fahrenheit, and for closure stresses from 6,000 to 10,000 psi. When you go into a deep, hot zone with phenolic coating—these are thermoset coatings—and the fracture takes a while to close, the proppant coating may have cured ahead of the fracture closing onto the proppant, with no adhesive properties left," he says.

Pearl's technology is designed to offer the advantages of both pre-curable and curable resins in one product, according to the Preferred Sands website. "The Pearl adhesive is different and sidesteps the problem. Pearl does not cure after it leaves the plant and its adhesive properties are unaffected by downhole heat, so you still get adhesion, or bonding. The key is that when the fracture closes, the adhesion is still there," McDaniel says.

Proppant demand has apparently swollen the ranks of coated-proppant suppliers. McDaniel says that about a dozen companies are now making resin-coated proppants, up from about three a few years ago, with most using the same phenolic technology. "Our price point is significantly lower than the phenolic competition," he says.

Another new proppant from Preferred Sands, like Pearl, introduced in 2012, is RCS Garnet. It is designed for low-temperature formations, and is suited for wells in western Texas, Colorado, Alberta and Oklahoma. Unlike other resin proppants, which require an additive to get the phenolic coating to bond quickly enough in cooler wells, which, in turn, can affect the frac fluid, "all that Garnet needs is water in the frac fluid," McDaniel says. He adds that sales for the product have taken off, as many in the industry are familiar with coated proppant problems at low temperatures.

Preferred Sands has a strategic alliance with The Dow Chemical Company, which provides raw materials, but all the intellectual property belongs to Preferred Sands, McDaniel says.

New additives for proppants are also entering the market. Sorb is a solid diatomaceous compound from Baker Hughes Incorporated with a large surface area that is added on site to the blender with sand. "It becomes part of the proppant stream. It needs to be adjusted for a few variables like formation pressure, temperature, etc.," says Virginia Wornstaff, a technical specialist at the Baker Hughes Calgary office.

The additive, which can account for between one and five per cent of the proppant, is designed to prevent blockages and sudden declines by keeping asphaltenes, scale and other formation fluid materials in suspension, and prevent deposition, says Wornstaff.

The range of formation conditions appears set to continue spurring R&D of targeted niche proppants. In concert with industry partners, the Petroleum Technology Alliance of Canada (PTAC) is involved in a couple of proppant R&D projects, says PTAC president Soheil Asgarpour. One involves R&D for an ultra-lightweight proppant with a high crush tolerance. The other is aimed at improving yields of natural gas liquids in gas wells. ■

PHOTO: PREFERRED SANDS, LLC

Eye On The Ball

Degradable drop-balls simplify hydraulic fracturing, removing obstacles to later re-fracking

At the end of a multistage fracturing job, most well operators expect improved production from the newly fracked well. Many also look for a clear path to re-frac the well later on.

In most horizontal fracking jobs today, drop-balls work much like roving valve plugs that isolate each stage of the operation. Balls of varying sizes are used to selectively open successive stages of the well.

Yet, not all drop-balls are the same. When fracturing is done, the standard ball is meant to be recovered from the well, usually from the frac fluid as it flows back to surface. Not all balls are recovered, however, and those left downhole could conceivably cause problems if the well is re-fracked, months or years later.

To remedy such problems, engineers at Packers Plus Energy Services Inc. spent a decade developing a degradable ball, largely to avoid the lost-ball scenario described above. Today, in most horizontal fracking scenarios, well operators can use Packers' StackFRAC degradable ball, which will begin to decompose soon after fracturing is complete.

Packers' latest degradable ball, dubbed the SF6D, is hard and strong enough to withstand plenty of heat and pressure before eventually flaking apart downhole, according to Dan Themig, Packers Plus president, who says the ball can bear pressures up to 10,000 pounds per square inch and still keep its shape. Packers' other drop-balls are rated at 4,000–6,000 pounds per square inch, while Packers' non-degradable, metal alloy balls can take pressures up to 15,000 pounds per square inch.

"People want a degradable ball so they'll have flow assurance," Themig says. "These balls don't hang around and cause flow problems later in the life of the well. Also, if you decide to later intervene in the well, there won't be balls in the way."

Packers Plus isn't the first to the degradable-ball party. Other service companies have similar technologies, although the mechanisms and rates of ball breakdown vary. One advantage of Packers' ball technology is its low specific gravity, Themig says. Packers' balls are easier to recover in the frac fluid because they're more easily carried along than some balls, he says.

Themig says drop-balls made by some manufacturers can get stuck in the ball seats. Wedged in tightly enough, those balls might not break up, or do so only slowly, creating major headaches for the operator. On the other hand, "our material tends to have fewer problems with that," he says.

Available in a range of sizes for common liner diameters, Packers' balls are designed to degrade in the presence of water in temperatures above 60 degrees Celsius, and to flake apart gradually in the days that follow. For most operators, disposing of the balls without having to drill or mill is a blessing.

Still, some hardware will remain downhole even after the balls have degraded. These are the ball seats, usually one for each frac stage, and when the balls are gone, the seats usually stay behind. That doesn't sit well with all operators, however, and some insist the seats be drilled out before putting the well on production.

There's another scenario, according to Themig, although it adds to the cost of completing the well. It applies when the operator knows he will have to re-frac later, in any case. In this scenario, the ball seats are left in place, but instead of a regular FracPORT sleeve, the operator uses Packers' Refrac FracPort sleeve on the original frac job.

The advantage is that, when it's time to re-frac, whether a month or a year later, the operator can re-enter the well with a special tool and close all the frac ports, one by one. From that point, fracking proceeds as usual.

StackFRAC degradable balls come in diameters from one inch up to just under four inches, and are sized in increments of one-eighth and one-sixteenth of an inch. While the sizing would appear to limit the maximum number of stages that could be fracked, Themig says two stages can be fracked with the same-size ball, using Packers' proprietary technology.

To date, the company has sold about 1,300 balls North America–wide, many of which have been used in fracturing operations.

In western Canada, the balls are typically run in such formations as the Bakken, Cardium, Montney and Swan Hills, according to Themig. As of late June, oil and gas companies have run a total of 282 SF6D degradable balls in 38 wells in Canada, and testing of the technology is continuing.

James Mahony

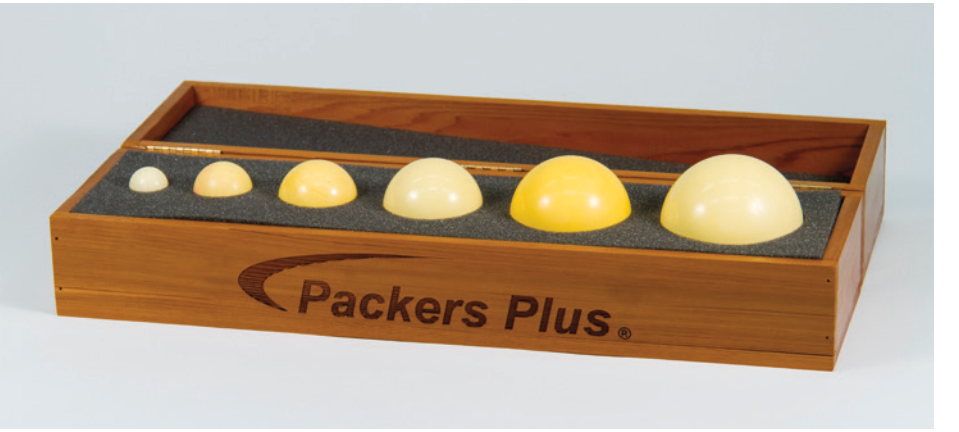

PHOTO: PACKERS PLUS

MADE TO MEASURE

Packers Plus StackFRAC degradable balls range from one inch up to just under four inches in diameter. Packers' proprietary technology allows for two stages to be fracked with the same-size ball, further increasing the number of fracs to be performed in a well.

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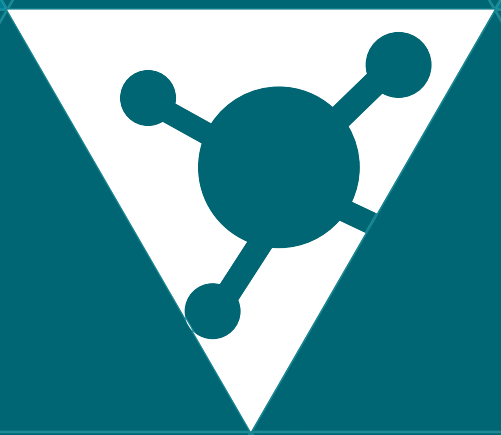


The turnaround in the fortunes of the oil and gas industry in North America has as much to do with tight oil and gas as it does with unconventional production from sources like the oilsands. Technologies developed to exploit tight reservoirs have effectively turned back the clock, making once passed-over fields thought to be exhausted productive again. New opportunities abound as companies work to optimize these new technologies.

Energy Transformation?

Natural gas assuming a bigger role in powering upstream and midstream operations

By Godfrey Budd

A portable 25-megawatt electricity generator is the linchpin of one of several systems and technologies that appear poised to significantly improve, if not transform, on-site processes for pad drilling and completions, especially in the unconventional natural gas sector. General Electric's (GE) TM2500+ offers multi-fuel flexibility and can run on either natural gas or a range of liquid distillate fuels. Its role in on-site pad operations is premised on relatively low natural gas prices continuing in North America over the long term.

Such circumstances have created opportunities for others to introduce technologies taking advantage of cheap natural gas, including Dresser-Rand Company working with Expansion Energy LLC to provide small-scale production of liquefied natural gas (LNG), and Caterpillar Inc.'s dynamic gas blending (DGB) retrofit kit, which went commercial a little over three months ago and is already being used by major service companies.

That is not to say, however, that better fuel economy via low natural gas prices is the only benefit stemming from technologies such as GE's generator on site. Far from it. Calgary-based Evolution Well Services selected a portable version of GE's workhorse gas turbine because it enables a new method of hydraulic fracturing that eliminates the need for a phalanx of diesel pump trucks.

When GE and Evolution Well Services provided a site demonstration of their concept on the outskirts of Lethbridge, Alta., in February, it was clear that big gains in operational efficiencies were part of the package, as well as dramatically reduced personnel requirements during fracking and a smaller carbon footprint.

Described by Evolution president Eldon Schelske as "fit for purpose," the system that he and his team have developed harnesses a network of off-the-shelf pieces of equipment to provide a process that is aimed squarely at large frac jobs in the pad drilling sector.

The GE power plant that provides the juice to the 2,500-horsepower pumps has been around since 1969, mostly as the non-portable LM2500+. Over 1,000 of these have been sold around the world. The TM version—TM stands for trailer-mounted—is quite new, and last summer the 100th unit was manufactured, says Lance S. Hall, the Houston-based general manager for GE's fast power portfolio.

Key to the thinking behind the Evolution system is that the scaled-up approach that is often applied, with about 50 site personnel or more and dozens of trucks, is poorly suited to today's large, complex pad completions.

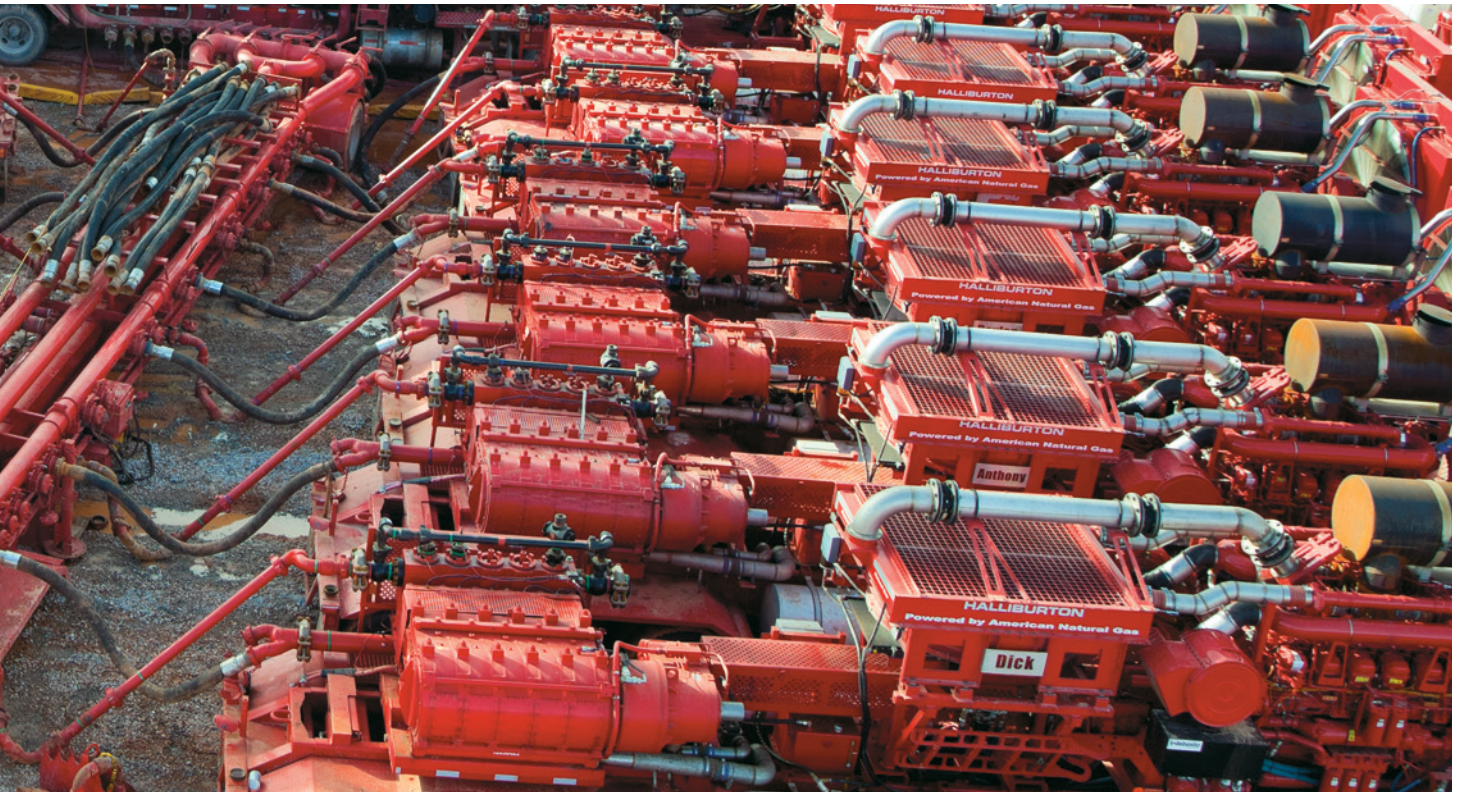
First, there is the issue of the trucks themselves. "The conventional diesel-fired pumping units don't have the capacity to run hard for eight hours," Schelske says.

Then there is the risky business of so-called hot fuelling. With trucks just 18 inches apart, the diesel-fired units, he says, are sucking very hot air, as ambient temperatures can climb as high as 180 degrees Fahrenheit. "The trucks are not designed for this set-up, with the heat and the length of time running at full power."

He says the risk of fire is considerable and cites an instance during a frac job when a fire started and destroyed about $32 million worth of trucks and other on-site equipment in eight minutes.

As Schelske points out, a frac job requiring about 30,000 horsepower running means that around 25 pump trucks will be necessary. "The guys in the trucks must react to the supervisor calling the frac—'Pick it up, slow down, etc.'—but it's easy to mishear. Pump capacity is at 45,000 horsepower. The frac supervisor is likely calling to two command centres as

PHOTO: APACHE CORPORATION



▲ **GROWING SMALLER**
Today's massive fracture stimulation jobs are evolving away from the use of dozens of trucks and their associated infrastructure to more compact operations utilizing fit-for-purpose power trains able to run on a variety of fuels.

there's often not enough space in the main shack," he says.

On the other hand, with Evolution's system, 60,000-horsepower capacity is achieved with six skids of pumps. There are four electric 2,500-horsepower pumps per skid. The modular configuration of pumps and skid means that any of the four pumps can be removed for service, leaving the other three behind. A replacement pump is easily installed. "Now, with 60,000-horsepower capacity, all we're adding is a turbine generator instead of 25 trucks, tanks for fuel [and] extra shacks for control centres. Our system has the six skids, a data shack and a motor control centre that allows for variable speed," Schelske says.

He adds that Evolution's system means a reduction of noise as well as fewer field workers and trucks.

He is proud of the fact the system has been developed from off-the-shelf equipment. The electric motors used are marine tugboat units made for high-torque applications. The finely calibrated control system enables a pump to run at 20,000 foot-pounds at one revolution per minute (rpm) for pressure testing. The Gardner Denver, Inc. pumps are also off-the-shelf, but their oversight is precise and responsive to conditions.

"The computer control allows for the automatic limiting of power to a pump experiencing any type of problem. The pump-monitoring system requires only two inputs—torque and rpm—instead of 14 with diesel-powered pumps. This frees the system to monitor other variables, like bearing temperatures, or vibration, individual pump cylinder pressure. It allows for very proactive maintenance," Schelske says.

The pump motors should operate for about 50,000 hours before they need to be opened up for servicing. That contrasts with the maintenance needs of a diesel unit, which can be every 200–300 hours. Removing a pump module from the master skid can be done with a 45-tonne crane. Based on horsepower and pumping capabilities, each master skid replaces five trucks, as unlike with a diesel-fired unit, there is no horsepower loss between engine and pump. It makes sense to have a few spare pump modules at the site partly because it is relatively inexpensive, Schelske says. "Three modules cost less than a tractor at the site."

Capital costs using GE's 25-megawatt power supply are about the same as for a typical array of pump trucks, but emissions are cut by about two-thirds and the decibel level is also lower. A field staff on site of eight to 10 can run fracs in the range of 30,000–60,000 horsepower, using Evolution's system. "That alone improves the economics as you're paying eight to 10 instead of 40–50 on-site guys," says Schelske, who was in charge of business development at Trican Well Service Ltd. before launching Evolution.

He is confident that interest in the company's innovative system, which was first tested in February 2012, will continue to grow. Both majors and others have booked Evolution's equipment. He says one thing that helped make what he describes as a leap of faith easier was that "no one has ever poked holes [in the concept]."

SMALL-SCALE LNG

The issue of portability, while taking advantage of natural gas availability and its low price, is close to the heart of the matter for another innovation targeting both upstream and downstream operations. Last October, Dresser-Rand Company, a subsidiary of Dresser-Rand Group Inc., announced an ▶

agreement with New York–based Expansion Energy. Under this, Dresser-Rand is granted a worldwide exclusive licence, for capacities up to 100,000 gallons per day, to Expansion's proprietary VX Cycle for the small-scale production of LNG.

"Dresser-Rand believes that the patented VX Cycle is the first technology to provide a cost-effective small-scale LNG production process with capacities as low as 1,500 gallons per day—far smaller than any other LNG production system commercially available today," said a Dresser-Rand press release last fall, explaining the licence agreement.

Brad Dickson, vice-president and chief marketing officer at Dresser-Rand, says that a $1–$2 difference between the per-gallon price of diesel and the LNG equivalent should hold in favour of the latter for the foreseeable future. "Price is the big driver. It's a huge opportunity," he says.

The interest in LNG is understandable, given the expectation of low natural gas prices over the long term. The energy intensity of LNG is almost two-and-a-half times that of compressed natural gas (CNG) and, at 60 per cent that of diesel and 70 per cent of gasoline, approaches the energy intensity of two of the commonest fuels, but is forecast to remain much cheaper than both of them. "LNG is being considered for long-haul trucking because the energy intensity is much greater than CNG," says Dickson.

Dresser-Rand has begun the process of developing a 6,000-gallon-per-day containerized plant that should be commercially available within about six months, with testing slated to start this summer. The advantages include the fact that such a plant can use flare gas as a feedstock and does not have to rely on pipeline infrastructure. Dickson says that Dresser-Rand's 6,000-gallon-per-day LNG production plants will come in three or four containers and include technologies to remove CO_2, heavy ends and other impurities in the gas stream.

As development is still pre-commercial, the price tag for a Dresser-Rand LNG plant using VX Cycle technology is still up in the air. Still, Dickson makes the point that the system from Dresser-Rand involves a relatively modest investment—"$5 [million] to $10 million per 6,000-gallon-per-day plant"—compared to the tens or hundreds of millions in capital costs commonly associated with larger LNG production facilities. Dickson says that the per-gallon cost of LNG from a mobile Dresser-Rand production plant should be about the same as that from a large facility.

VX Cycle is especially suitable for remote locations because it is modular, portable and makes its own power, says Jeremy Dockter, co-founder and managing director at Expansion Energy.

Its infrastructural requirements are modest. "Most designs for large-scale LNG production require a high-pressure feed gas—from 300 to 1,000 psi [pounds per square inch]. But we can use 55 psi, resulting from a balance of refrigeration and compression," says David Vandor, a co-founder and chief technology officer at Expansion.

Also, unlike conventional large-scale LNG plants, VX technology uses one compressor for both the natural gas feedstock and refrigeration. "VX uses a methane expansion cycle in a microenvironment and involves recycling of the expanded low-pressure natural gas, typically used for pipeline-based peak shaving plants. So this is a new application for a methane expansion cycle," says Vandor.

> *"Now, with 60,000-horsepower capacity, all we're adding is a turbine generator instead of 25 trucks, tanks for fuel [and] extra shacks for control centres. Our system has the six skids, a data shack and a motor control centre that allows for variable speed."*
>
> — Eldon Schelske, president, Evolution Well Services

FUEL DIVERSITY

Another fuel technology that is sparking interest is the DGB retrofit kit from Caterpillar. The company announced in December that it had shipped the first unit to a Russian oil and gas company. The technology allows customers to use a range of gaseous fuels in their existing diesel-fired generator sets, drilling and pump motors. Caterpillar's December 6 press release noted that, "The kit also recently successfully completed an extensive field test for Encana Oil & Gas (USA) Inc."

The DGB kit is designed to adjust automatically to changes in incoming fuel quality and pressure, allowing engines to run on a variety of fuels, from associated gas to vaporized LNG, with no loss of performance. Initially designed for gen sets, Caterpillar is now marketing its kit for a broad range of heavy diesel applications. This has added complexity, however.

"With a mechanical drive, the challenge becomes the feedback mechanism needed, as the output power of the pump has to be matched to the input control of gas. If you get that wrong, you over-fuel the diesel engine with natural gas," says Todd Krueckeberg, product manager, land drilling and production.

Other companies are taking an interest. Barely a month after the December 6 announcement of first shipment, Halliburton announced in January that Caterpillar had "adapted its proprietary dynamic gas blending engine technology to power Halliburton's massive pumps."

Caterpillar collaborated with Halliburton and Apache Corporation. Neither is using site gas yet, but both have plans to in the future. "We want to give Caterpillar time to refine its software," says Michael Bahorich, Apache's executive vice-president and chief technology officer.

By early January, engines for frac jobs in Apache's Granite Wash operations near Elk City, Okla., were running on CNG on the Schlumberger side and LNG for Halliburton. Better infrastructure could be just around the corner. In partnership with OsComp Systems, Inc. and Schlumberger, high-rate filling stations are being built to fill tube trailers with CNG that go to where the pump trucks are working. "The gas is taken from the sales pipe of a plant. I don't think anyone has done this before," Bahorich says.

If low gas prices hold, expect an expansion of uses for it in transportation, Bahorich says, noting that 100 billion pounds of sand will be shipped annually in the near future as the unconventional gas sector grows. "We should use natural gas for that," Bahorich says. ■

Faster, Cheaper Fracs

World's biggest continuous multistage fracture program completed in record time

Nexen Inc.'s early drilling pads in the Horn River Basin of northeastern British Columbia had less than a half dozen wells. But in the winter of 2011, the operator drilled 18 wells on a pad. So when it came to doing the completion on these wells last summer, economies of scale kicked in, enabling various efficiencies. That is not to say the company was not already pursuing ways to boost completions' efficiencies and cut costs. In the Horn River, operators can expect to spend around 65 per cent of the total cost of a well on the completion, says Kevin Lypkie, an engineer and completions lead for Nexen's Dilly Creek operations in the Horn River.

Given the potential efficiency gains from multi-well pad drilling, it is no surprise that operators in Canada are following a trend in the United States of pads with 15–20 wells. Also, as reported in this magazine and elsewhere, the Horn River play has already been the location of other large-scale hydraulic fracture jobs. In the wake of a 16-well pad completion done in the winter of 2010, Apache Corporation trumpeted the world's biggest frac job. The company had completed 274 frac stages in about three and a half months.

Today, Nexen management believes they can now lay claim to the world's biggest continuous frac program and, more to the point, in record time. Between 2:20 p.m. on June 30 and 10:52 p.m. on August 21 of last year, at Pad B-77-H, a total of 330 frac stages were done with 881,000 cubic metres of slurry pumped, whose volume included 66,000 tonnes of sand. The roughly 52 days it took to complete the wells on the Nexen pad almost precisely cut Apache's time (111 days in 2010) in half on a 16-well pad. "Others had done big frac jobs. The time we pulled it off in was the big step-change," Lypkie says.

He and his completions team at Nexen deployed various tactics and techniques to get the huge completion program done as fast as possible.

An important aspect of a frac job is the designed rate. It refers to the rate at which the frac fluid is pumped downhole. Suppose the rate desired is 100 barrels, or 16 cubic metres, per minute. How long it takes the pumping action to reach that rate can significantly affect how many frac stages get done on a particular day. "We put a lot of focus on how fast we got to design rate. You can take an hour, or, if you try, you can make it in a lot less time to design rate," Lypkie says.

Small incremental improvements of this sort can make a significant difference on a large frac job. At B-77-H, it took an average of 17 minutes to hit the designed rate. "If we had taken an hour—that's about an extra 45 minutes—that would bring the number of frac days from 52 to 62 on the job," Lypkie says.

Time savings like this can save millions of dollars on a large frac job. Depending on sand prices and other factors, industry average costs on multi-well pads in the Horn River region are $1 million to $1.5 million per frac day.

The time between stages can also present an opportunity for savings. Lypkie says the average time between fracs was cut by 75 per cent. In 2012, elapsed time between fracs averaged 40 minutes, but this dropped sometimes to 10 minutes, or even six, on occasion.

On B-77-H, plug-and-perf completions were done using a wireline on the two banks of nine wells. Each well received 18 or 19 fracs along the 2,000- to 2,400-metre laterals.

Godfrey Budd

▲ FRAC ATTACK
It may not look very tidy, but once all the equipment was in place, Nexen was able to set a new standard by fracking 330 stages on a multi-well pad drilling operation in northeastern British Columbia in just 52 days.

PHOTO: NEXEN INC.

Clearing A Path To Production

Fracturing technology simplifies retrieval of downhole hardware after fracturing, easing future wellbore re-entry

By any measure, the development of open-hole fracturing for long-reach horizontal wells has been a blessing to the oil industry, letting producers tap hydrocarbon reservoirs previously considered exhausted using conventional stimulation methods.

When fracturing is complete, however, most of the technologies currently available leave the hardware—usually a liner and several ball-and-seat assemblies—solidly fixed in the wellbore, where it stays for the life of the well. Later, if an operator has to re-enter the wellbore to perform workovers, for example, the hardware can become an obstacle, limiting the diameter of tools that can be used.

Still, industry has found ways to work around or through the problem by going back into the well to mill or drill out the remaining ball-and-seat assemblies. While doing so represents an adequate fix of the problem, it's an expense most well operators would rather avoid, if possible.

One company that's tackling the problem is Suretech Completions Canada Ltd., a unit of Sanjel Corporation that has developed a retrievable ball-and-seat technology. After fracking is done, the well operator can use the SUREstack system to pull the ball-and-seat assemblies from the well in a single operation, clearing a path for later re-entry, should further downhole operations be needed.

According to Suretech engineering manager Darryl Firmaniuk, SUREstack's biggest advantage is that it allows well operators to remove ball-and-seat assemblies without milling or drilling, thereby avoiding the extra cost and time such work involves (milling can cost $80,000 or more per well).

"At the end of the day, [the SUREstack system] gives you a full-bore opening so you can go in with remedial equipment in the future, and you don't have to worry about any type of restrictions in the wellbore that you have to flow through to produce the well," Firmaniuk says.

In the current marketplace, there are fracturing systems in which "a lot of extra money is spent drilling out balls and seats, but very few companies have a retrievable seat system."

With traditional fracking systems, to get full production from the well, the operator needs to get rid of balls and seats in the traditional frac sleeves, Firmaniuk says. However, for wells without much reservoir pressure, there's often not enough pressure to push the balls from their seats back to surface in the drilling fluid, so they stay behind, obstructing production.

"If you don't flow [the balls] back to surface, the customer has to make a decision," he adds. "Does he want to go ahead and drill out the balls and seats? Typically, [to do so] we'd go in with coiled tubing, a mud motor and bit, and drill [them] out in the wellbore. That can be somewhat time-consuming, if it doesn't go according to plan."

▲ FULL-BORE OPENING
Developed by Suretech, the retrievable ball-and-seat SUREstack system became another tool in the Sanjel toolbox when it bought the company and its technology.

Using SUREstack instead of milling, the well operator can go in with a retrieving tool, starting by securing the top seat in the uppermost frac sleeve. "You engage it, using tension to remove the ball and seat from the chassis of the valve, then pull up and make sure you're free of the valve. Then you grab the next ball-and-seat [assembly] for the next valve, and repeat the process as you go down the wellbore," he says.

In effect, the whole retrieval process is done in a single operation without exiting the wellbore. On a technical point, Firmaniuk says Suretech's customers often want to return balls and seats to surface for inspection and analysis. Unlike milled-out components, those that are retrieved may offer information about the fracturing operation or liner-integrity issues. Still, about half of the customers prefer a second option, which disposes of components in a sump area downhole at the bottom of the liner.

PHOTO: SANJEL CORPORATION

NO MORE MILLING

Suretech's retrievable ball-and-seat multistage fracking technology ensures a full-bore opening is maintained after fracking, without the need to mill or drill out non-retrievable hardware.

PHOTO: SANJEL CORPORATION

Among Suretech customers who prefer to remove all ball-and-seat assemblies from the well was one producer working in central Alberta's Pembina area, which Suretech described in a case study. In that case, the producer wanted to regain use of the wellbore's full inner diameter after multistage fracturing. It required seven seats and one hydraulic port to fracture the well, drilled to 3,060 metres, with the deepest retrievable seat at 2,861 metres.

After completion of fracturing, Sanjel's coiled tubing was used to pull out all of the balls and seats at an average retrieval rate of two minutes per seat, according to Suretech. Compared to traditional drilling and milling, the operation effectively reduced the total time required to remove the seats by 90 per cent, Suretech said in its case study (results were not independently verified).

On the market for about a year now, the SUREstack system was invented by Suretech founder Sean Campbell, a Canadian whose company was later bought by Sanjel and now operates as one of the latter's Canadian divisions.

Among Canadian companies specializing in fracking long-reach horizontals, few currently offer a fully retrievable ball-and-seat system like Suretech's. One alternative, being developed by at least one other competitor, involves a degradable ball system, in which the drop-balls used in fracturing breakdown and dissolve in the drilling fluid and are pumped out of the system, avoiding the need to mill them out. The valves that control flow between zones can be reset for reuse later, say, in re-stimulating the well.

James Mahony

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Data Management & Software

More and cheaper data, moving faster than ever, has created many opportunities for improved software and data management at every level of oil and gas production. But with the opportunity has come new risks as competitors—and less scrupulous adversaries—probe for weaknesses in defences to protect the vast networks of information that have become so vital to the industry.

Cyber Attacks—A Growing Threat

Hackers are stealing trade secrets, proprietary technologies, business strategies

By Godfrey Budd

The exploitation of computer networks for espionage and other hostile activities is a growing menace to businesses and governments in North America. Commonly called cyber attacks, these electronic intrusions typically rely on one or two of several types of malicious software known as malware—including viruses, worms, Trojans, bots and backdoors—to steal information or money, destroy data or commit acts of sabotage like disabling systems and networks.

Often, the attacks are designed to gather confidential information on corporate strategy and plans, government policy or proprietary technologies. Reports suggest that this type of spying, as well as the potential for digital era–style acts of sabotage, has been growing by leaps and bounds lately.

At the World Petroleum Congress in Doha, Qatar, in 2011, oil company executives said that cyber attacks were becoming more frequent and better planned, according to a Reuters story last December. An IT expert at the conference warned that the Stuxnet computer worm, which was specifically designed to subvert industrial systems and surfaced in 2010, changed the world of international oil companies because it was the first such attack to directly impact process control. In the computer-controlled, automated global energy sector, this type of malware could wreak havoc by subverting controls on equipment. The misuse of valves, for instance, could cause "huge damage," the expert said.

The Stuxnet worm also demonstrated that innovative malware could be introduced into a system that was isolated from any external network, like the Internet. Believed to have been developed with the support of the U.S. and Israeli governments, the worm, which affected controls, wound up causing damage to centrifuges at a nuclear facility in Iran. It was delivered by a memory stick.

Iran, which is under international trade sanctions arising from its nuclear program and a dispute over its real nature, has had other major malware-related headaches. In April 2012, a virus infected the country's oil ministry and national oil company networks, forcing the disconnection of control systems including those at Kharg Island, the location of a key export facility.

▲ OIL AND GAS TARGETED

Recent evidence shows that both major international oil companies and state-owned producers have been successfully targeted by cyber attacks, resulting in theft of sensitive information and acts of sabotage.

Although a wide range of sources point to significant growth in cyber attacks, with one recent report from Symantec Corporation indicating an annual increase of about 25 per cent, getting a handle on the true level of cyber mayhem targeting businesses and governments around the world can be difficult. For one thing, companies that discover their networks have been hijacked tend to keep quiet about it, often leaving shareholders and clients in the dark. Sometimes, they are unaware of the problem at all.

Bloomberg News published a story in the summer of 2012, which was widely circulated, about a gang of so-called "patriotic

PHOTO: MAVERICK PUBLIC RELATIONS

hackers," with IP addresses in Shanghai and strongly suspected by experts of ties to the Chinese government. When reporters working on the story contacted 10 victims of the Shanghai-based Comment Group, they found that those that had learned of the hacks had not disclosed them publicly. Three of the 10 had been unaware of any cyber attack at all until reporters contacted them.

Some sectors are perhaps getting targeted at a far more rapidly increasing rate than Symantec's 25 per cent, which is based on global averages. Intrusions against computers that run essential infrastructure in the United States increased seventeenfold in the period of 2009-11, according to General Keith Alexander, chief of U.S. Cyber Command and director of the National Security Agency. He called the loss of industrial information and intellectual property through cyber-espionage "the greatest transfer of wealth in history," reported the *New York Times* last summer.

Reliable estimates on the economic cost of these attacks are hard to come by, as one would expect. In the spring of 2012, the U.S. Federal Bureau of Investigation said that cyber-espionage had cost U.S.-owned businesses $14 billion over a six-month period. But, given the under-reporting and other factors, experts have said that the figure probably represents a fraction of the problem.

Although perhaps more aggressive than most, the hacking activities of the Comment Group are indicative of a trend in which cyber-espionage appears to be tied to government agendas, or areas of interest, in the view of some experts. The *Bloomberg* story said that in case after case, "the hackers' trails criss-crossed with geopolitical events and global headlines."

In short, some governments have apparently embraced network hacking and cyberspying with gusto.

A couple of examples: when European Union (EU) leaders were negotiating on the Greek financial crisis, it was found that the cyber-equivalent of a wiretap had hacked into the EU president's office with the apparent objective of gathering vast amounts of intelligence over weeks, or perhaps months. Closer to home, in July 2011, hackers accessed the network of the Immigration and Refugee Board of Canada.

Starting with computers in Toronto, the logs from Cyber Squared Inc., an Arlington, Va.–based cybersecurity firm that monitors Comment Group activities, show that hackers busted into the board's network across Canada, grabbing and decrypting passwords, and finally gained access to the computer of a Vancouver-based adjudicator, Leeann King, who had made headlines less than a week earlier after temporarily freeing a Chinese national near the end of a long extradition fight, which he eventually lost. The whole hacking operation took only five hours.

Cyber Squared, on its website, says that oil and gas is one of several sectors, including telecommunications, financial services, law firms, public relations firms with dealings in China, think tanks, research organizations and the health-care industry, that are being increasingly targeted.

Various government agencies and organizations are also raising the alarm. The Canadian Security Intelligence Service (CSIS) report for 2010-11 said that attackers targeted networks of two federal government departments in January 2011—finance and the treasury board. The federal government, it added, was seeing "serious attempts to penetrate its networks on a daily basis."

Canada's auditor general, in his latest report to Parliament, highlighted concerns among senior civil servants that "the cyber-threat environment is evolving more rapidly than the government's ability to keep pace."

THE USUAL SUSPECT(S)

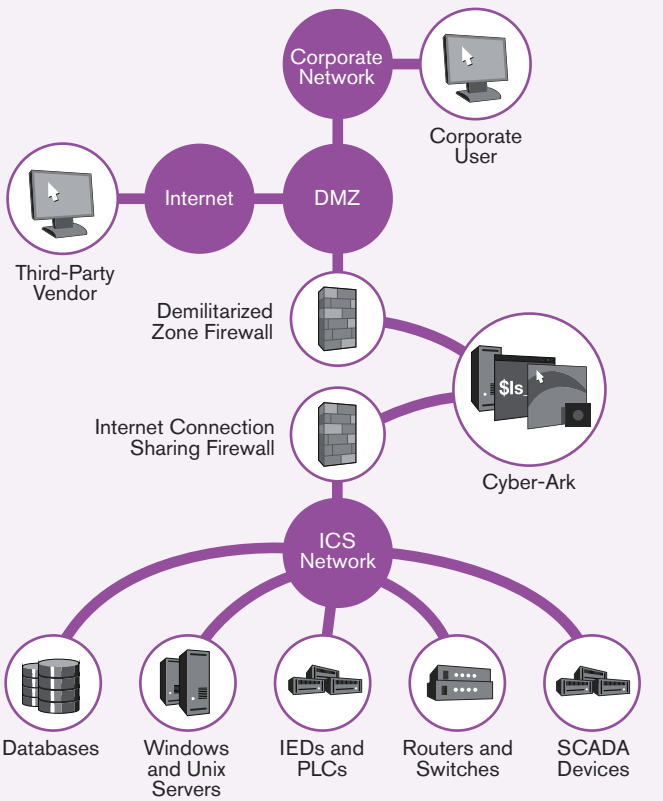
Aside from government, other sectors being targeted are aerospace, high-tech, oil and gas, and universities doing research. "In addition to stealing intellectual property, state-sponsored attackers are also seeking any information which will give their domestic companies a competitive edge over Canadian firms: an example would be inside knowledge of upcoming negotiations—personalities involved, their likes and dislikes, and so on," said the CSIS report.

A couple of years ago, CSIS director Dick Fadden made headlines after saying that some provincial cabinet ministers were under foreign influence. He was indirect about the precise source of foreign interference, but indicated that China posed concerns.

Although U.S. reports sometimes target Russia, China is likely a greater focus for the American cybersecurity community. A report prepared by Northrup Grumman ▶

▼ NETWORK SECURITY

A typical utility company runs networks connected through a demilitarized zone (DMZ) network. Using solutions like Privileged Identity Management Suite from Cyber-Ark Software, Inc., a network security company, both internal administrators and remote vendors can have a secure connection to the network while isolating the critical infrastructure from threats such as malware.



SOURCE: CYBER-ARK SOFTWARE INC.

Corporation for the U.S.-China Economic and Security Review Commission would appear to underscore worries about threats to cybersecurity emanating from China. Designed as an open-source reference for policy makers, China specialists and "information operations professionals," the *Report on the Capability of the People's Republic of China to Conduct Cyber Warfare and Computer Network Exploitation,* released in 2009, said that China was "a decade into a sweeping military modernization program that has fundamentally transformed its ability to fight high-tech wars."

One of the priorities of this modernization effort is computer network exploitation which, ideally, would mean achieving state-of-the-art intelligence-gathering capabilities conducted through the use of computer networks to scoop data from target or adversary automated information systems or networks.

For a recruitment drive in support of its burgeoning information warfare capabilities, the Chinese military has been casting the net wide for people with specialist skills, across the commercial and industrial sectors, academe and "possibly select elements of China's hacker community," according to the 88-page report.

It says that many aspects of the modernization effort are based on the view of Chinese military strategists who see information dominance as the precursor to overall success in a contest or conflict.

U.S. Congressman Mike Rogers, chairman of the House Permanent Select Committee on Intelligence, in early October urged Canadian companies not to do business with Chinese telecommunications giant Huawei Technologies Co. Ltd. The intelligence committee had just released a report describing the company as a threat to U.S. national security.

Although the warnings about Huawei have been dismissed as "politics" by some, the United States, India and Australia have banned Huawei from bidding on supplying equipment for networks considered part of critical infrastructure—oil and gas pipelines or the electricity grid, for example.

In Canada, Huawei is a supplier of networks to Bell, Telus, SaskTel and Wind Mobile.

Clients of telecommunications suppliers need to be sure that the equipment they buy does not include some malware that "phones home" and relays the data running through a supposedly secure network back to some hostile "mother ship." Also, a so-called backdoor within a switch's software could enable unauthorized third parties to listen in, participate or even control a network. Experts note that both methods can be used with network switches. "The problem is that everything on a network goes through switches. You want to scrutinize companies that sell you them," says David Skillicorn, a computer science professor at Queen's University who has testified about cybersecurity before Parliament. He says it is even more important for switches to be free of such malware than it is for laptops.

Certainly, there have been questions about Huawei's practices over the years since the Chinese company was founded in 1987. In 2003, Cisco Systems Inc. launched a suit against Huawei for copyright infringement. Although Cisco eventually dropped its lawsuit, that didn't happen until independent confirmation that Huawei, as a result of the legal action, had stopped selling disputed switches and routers, and changed its manuals and software.

Also, Brian Shields, a former senior security adviser with Nortel Networks Inc., a telecommunications and network equipment manufacturer that filed for bankruptcy protection in 2009, has gone public in the last year with allegations that the company was targeted by hackers based in China. He says that the attacks continued for years, likely compromising everything from proprietary technologies to confidential financial data and strategic plans. Experts interviewed for this article consider these charges credible. "Evidence points very strongly that Nortel was hacked," Skillicorn says. Shields has also been publicly warning against buying from Huawei, which he alleges was involved in some of the Nortel hacks, although he says he cannot prove it. Nortel once accounted for a third of the total market value of the Toronto Stock Exchange.

The tools for the Nortel raids have been around for a long time, well before they began, likely around 2000. But a dozen or more years ago, network defences were thinner on the ground than they are today—although the term firewall (for network security) was coined in the 1983 movie *WarGames*, which featured a hacker.

OIL AND GAS MAJORS HACKED

Despite better overall protection, however, and although the oil and gas industry is regarded by experts as relatively diligent about security, some weak links have been exposed in a series of cyber attacks over the last two years.

The U.S. natural gas pipeline system was targeted in a series of cyber raids, likely beginning sometime in 2011. Pipeline operators were hit with "spear-phishing" attempts—correspondence that masquerades as an internal message or coming from some other reliable source in order to gain information like usernames and passwords.

In August 2012, the Saudi Arabian Oil Company (Saudi Aramco) was targeted and 30,000 workstations were infected with a virus. Data was destroyed and replaced with an image of a burning American flag. The isolated networks for production were not affected, according to the company. Days after the Saudi Aramco incident, Qatar-based RasGas Company Limited was forced to shut down its website and email systems because of an attack. Saudi Aramco was probably hit by a virus called Shamoon or Disstrack which attacks computers running Windows NT and is being used for cyber espionage in the energy sector.

In early 2011, it emerged that the networks of several oil and gas companies, including some U.S. and European majors, had been hacked over a lengthy period, perhaps starting in 2008 but no later than November 2009. The purpose of the hacks appears to have been the theft of valuable or sensitive information, including deals, legal matters and financial data. Hackers had also targeted electronic topographical maps. In some instances, hackers had undetected access to company networks for more than a year, according to one investigator. A report by the security firm McAfee Inc. described some of the techniques used to hack company computers as "unsophisticated" and commonly used by Chinese hackers.

In September 2012, Telvent Canada Ltd. learned of a breach of its internal firewall and security systems. In a letter mailed to customers, a copy of which was obtained by blogger Brian Krebs of *Krebs on Security* and was quoted on his site, the Calgary-based company said that the attacker(s) had installed malicious software and stolen project files related to one of its core offerings, OASyS SCADA. Telvent makes software for remote support services in the energy sector, including pipelines.

Krebs' account of the Telvent breach referred to an accompanying image from a photocopied document on the malware and network components involved, and said that they "strongly suggest the involvement of Chinese hacker groups tied to other high-profile attacks against Fortune 500 companies over the past several years."

PHOTO: MAVERICK PUBLIC RELATIONS

Schneider Electric SA, a French energy conglomerate and owner of Telvent, responded to a request for an interview with a prepared statement. It said that Telvent was working with law enforcement, security specialists "and our affected customers to ensure this breach has been contained."

NEW WAYS TO BREAK IN, GRAB INFO

It's not just Fortune 500 companies that are targeted. An estimated 18 per cent of attacks target companies with fewer than 250 employees, while about 50 per cent are aimed at ones with fewer than 2,500. The attacks are trending up for companies with fewer than 250 employees and governments are the targets of about 25 per cent of all attacks worldwide, says Kevin Haley, director of security response at Symantec Corporation. One of the lures drawing hackers to small businesses (fewer than 250 employees) is the customer or client lists. "But it is just as likely to be intellectual property," he says.

Smaller firms might also be hacked as a means of gathering intelligence about a large client or project. Haley says this has happened in the defence industry. "The bad guys wanted to find out about a defence program, so they got in via a small contractor."

Some of the targets may be small companies, but the complexity and sheer volumes of data are enormous. Haley says security companies have to be able to handle these volumes as it is "a waste of smart people to have them search a haystack for a needle. You need a system that can handle huge amounts of data. We have the ability to process big data."

Another area of risk potentially providing a vector for unauthorized data capture is the conventional operations network. "Control systems out in the field are not afforded the protection available for the enterprise environment," says Walter Sikora, vice-president for security solutions at Industrial Defender Inc. The risk, he suggests, is that malware could move along a network from controls to the enterprise part.

The U.S.-based company, which provides automated security, compliance and change management solutions for the chemical, oil and gas, and electric utilities sectors, was in the news last September when Telvent announced it was partnering with Industrial Defender to improve cybersecurity.

Another factor potentially increasing the cyberthreat could occur in the case of a company whose senior management has ties to a hostile regime overseas, says Tom Keenan, an environmental design professor and a research fellow at the Centre for Military and Strategic Studies at the University of Calgary. "Invoices, for instance, go back and forth. The level of security varies among companies. Bad code could be buried in an invoice. More interaction means more opportunity."

Also adding to the data vectors for spies is the increasing use of mobile devices with access to networks and supervisory control and data acquisition systems, says Douglas Gray, president of Graycon Group Inc. He makes the point that an office lunchroom with a wireless hot spot could wind up being used for something more than collegial talk over laptops and lattes. The hot spot might extend to another floor or two, potentially exposing an internal discussion to an outsider.

▲ CYBER-ATTACK DEFENCE

Many types of security breaches are easily preventable and at little cost through education, training and the willingness to follow a few rules, experts say.

TIPS ON LOW-COST CYBERSECURITY

The good news, as Gray and others point out, is that many types of security breach are easily preventable and at little cost. ►

Experts say somewhere between 80 and 95 per cent can be prevented with education, training and the willingness to follow a few rules.

Take cloud computing, which involves entrusting a remote service provider across a network, typically the Internet, with a user's data, software, etc. If human resources moves data to the cloud without informing IT or the legal department, data could be vulnerable. When a university recently migrated scheduling, personnel and working data to the cloud—and left others in the dark about it—the university's IT department wound up scrambling to plug the security holes. "When people move stuff to the cloud without IT or legal checking it, you have exposed a firm to risk," Gray says.

He says that as non-IT people have become more tech savvy, they feel able to act more autonomously on IT issues, but they're sometimes unaware of the specific security issues related to what they do. Gray says IT has to move away from the traditional top-down model. "IT needs to be an enabler so that then things are done safely," he says.

Trustworthy providers are a common sense part of security, says Skillicorn. "The problem with Huawei is no one really understands the relationship between the company and the Chinese government. There's a reason we don't buy fighter jets from the Russians. It's not just a market." ■

Bringing It Together

Software helps track capital costs, complete the financial face for oil and gas producers

The oil and gas industry is a highly capital-intensive business, with companies spending millions of dollars drilling wells each year. In a volatile world where producers are beholden to wild swings in commodity prices, it's critical that companies are able to track their spending. This allows them to react quickly to changing market conditions.

To help producers do this, and be able to accurately forecast future spending, Calgary-based software company COGS Solutions released the new version 6.5 of its flagship interCALM (Integrated Capital Lifecycle Management) software. It's a commercial software application tailored to the upstream oil and gas industry, to provide full life-cycle management of current and future capital programs.

The company is also developing new software, interVIEW, which will put in focus the overall financial picture for an oil and gas organization.

Glen White, president of COGS Solutions, says the company's applications are designed to "eliminate the chaos" so that producers always have a pulse on their organization's financial status and can forecast future spending.

"Integration is key to us," he says. "Everything we've built on this whole platform is about being able to integrate with other industry-standard applications. InterCALM builds bridges between established business processes and embraces the concept that capital management should never exist in isolation from the rest of the company."

InterCALM 6.5 allows producers to define their long-range plan, carry out annual programs and greatly reduce the time spent reconciling budget to actuals, and aids in making proactive decisions to ensure publicized targets are met.

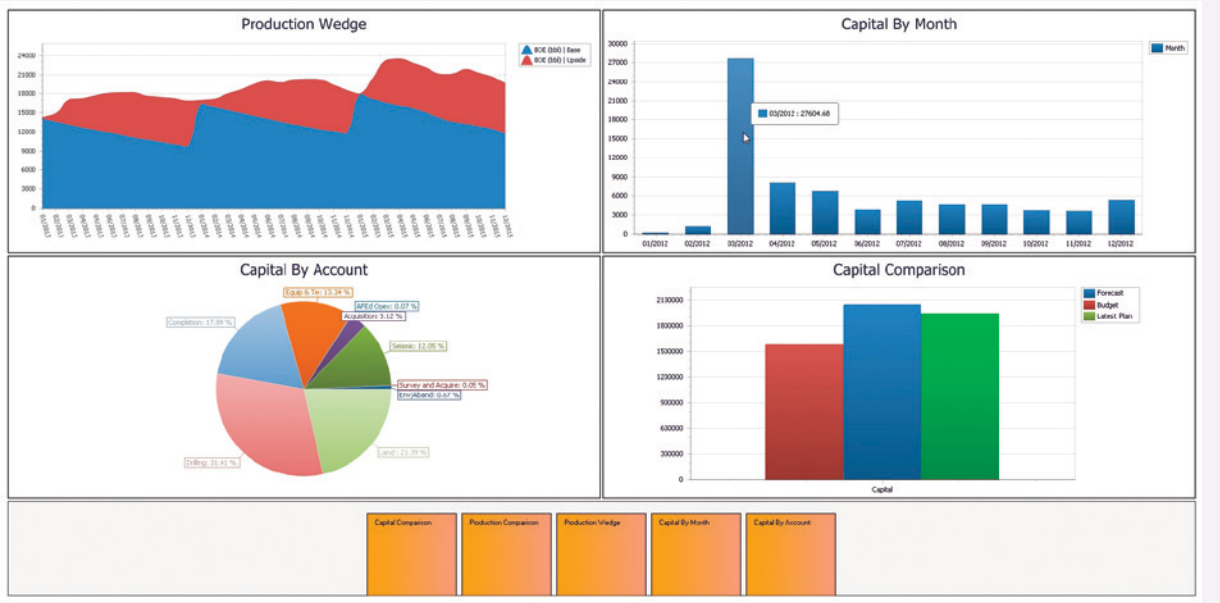
"With integrated budgeting, forecasting, full [authority for expenditure and request to drill] workflow and resource scheduling [among other features], there is no other tool on the market that brings together more business processes into one centralized application," notes Duncan McDonald, technical director with COGS. "Aside from the obvious cost savings of replacing several disparate systems with one, interCALM simplifies the jobs of…project teams while providing the truth in the numbers that management, directors and shareholders today demand."

John Yeo, business development engineer with Birchcliff Energy Ltd., says the company started using interCALM software because it needed a budgeting solution to replace its Excel spreadsheet–driven tool that met several criteria. Those prescribed standards included that the software must be straightforward and robust, it must be multi-user, it must conform to the company's business process, and it must have capital and production forecasting at a daily granularity.

> *"Integration is key to us. Everything we've built on this whole platform is about being able to integrate with other industry-standard applications."*
>
> — Glen White, president, COGS Solutions

"[We] chose interCALM as it met our criteria, plus it was able to integrate very well with our accounting data and Hyperion Essbase [multi-dimensional database technology], and helped to further improve our business process," he says. "The support/development team at COGS are also very easy to work with and quick to incorporate necessary changes."

The software has helped Birchcliff with standardization and reliability, allowed for tighter capital forecasting



▲ SIMPLIFYING CAPITAL MANAGEMENT
InterCALM software allows oil companies to simplify the capital budgeting process and change their outlook on capital.

and tracking, and reduced the budget-cycle time because of a repeatable project set-up.

"[It has allowed for] easier and faster corporate forecasting," Yeo says. "[It's] tightly integrated with our corporate forecasting model, allowing us to capture major changes or model alternative scenarios within a couple of hours."

Lawrence Backmeyer, manager, exploitation engineering, with Lightstream Resources Ltd. (formerly PetroBakken Energy Ltd.), says the producer started using interCALM in mid-2010 to track its capital expenditures, and the associated volumes and reserves. The main benefit of interCALM is that it allows for detailed information/variance associated with capital being spent, compared to production on a barrel-of-oil-equivalent basis per day and reserves per barrel of oil equivalent.

"The company can see how changes in capital affect the [per-barrel-of-oil-equivalent] production and reserves for the year, or monthly, exit-rate production," he says. "The company can also accurately track capital spending on a month-to-month, project-by-project basis throughout the year."

The product is fully integrated into Lightstream's accounting system, where expenditures are automatically updated every month, allowing the company to track expenditures monthly against its forecast. "Each project—well or facility—is tracked separately so everyone involved in the project can see how the project is progressing from a capital expenditure/timing prospective," Backmeyer says.

Eric Ewin, director of client services with COGS, adds that the soon-to-be-released interVIEW software will help to complete a "financial face" for oil and gas companies.

"InterVIEW is a finance-focused application that enables oil and gas companies to put a complete financial face on their capital plan and operating activities. In addition to capital and volumes, interVIEW covers revenue/price modelling, royalties, detailed fixed/variable operating expenses, G&A [general and administrative expenses], debt and cash-flow modelling. It provides complete income statement, balance sheet and cash-flow statements."

Key features of interVIEW will include flexible price-modelling capabilities with an ability to apply corporate assumptions with detailed wellhead pricing factors.

Integration with interCALM, industry-leading economics engines and financial applications, along with other source systems, will allow for automatic updates of the latest capital expenditure, production volumes, royalty rates and historic data to speed up the budget or forecasting process, eliminating redundant data entry and errors. It will incorporate detailed production/operating, general and administrative, transportation and other expense calculations, either based on per-barrel-of-oil-equivalent or fixed amounts, pre-seeded or based on historic actual costs.

The software will feature a "what-if" analysis based on different capital plans, pricing scenarios or acquisition/disposition activity. InterVIEW will also feature full cash-flow and debt modelling to provide a snapshot of the overall company financial forecast based on current operational plans, among several other features.

McDonald adds that the company's applications are highly configurable so they can be matched to a particular company's workflow and business process.

"Though our support is second to none, we provide our clients with the knowledge and tools they need to operate as they see fit and on their own schedule. That model allows us to maintain close communication with our clients to discuss real-world user experience and garner feedback, which we use to continually improve our software."

■ ***Richard Macedo***

IMAGE: COGS SOLUTIONS

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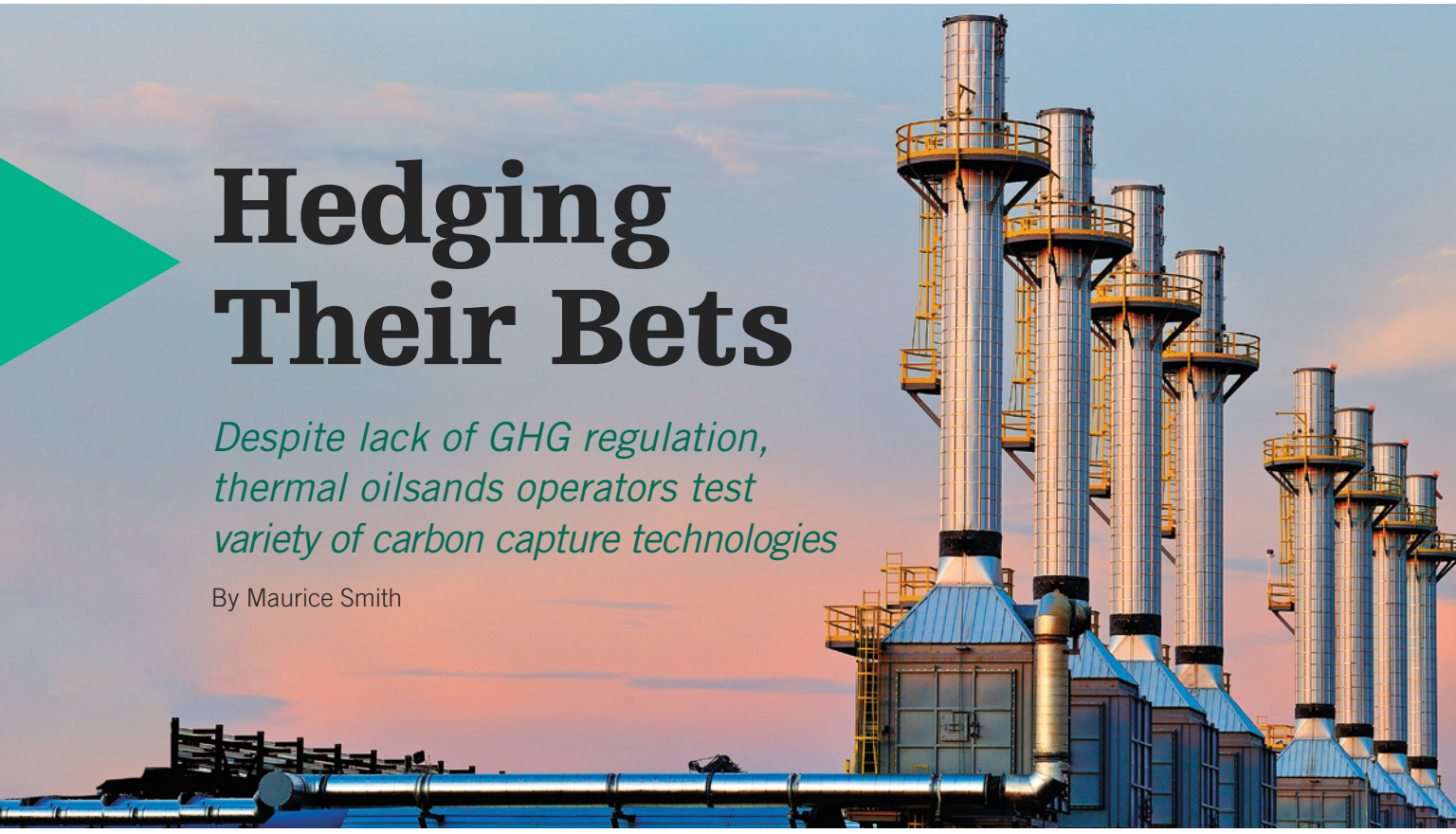
Health, Safety & Environment

Managing the health and safety of workers and the public and reducing the impact on the environment have rarely been at such a high level of public scrutiny. Properly managing concerns about all forms of oil and gas transportation and reducing emissions that rise almost as quickly as production are vital to maintaining social licence to operate. It also makes good business sense.



Hedging Their Bets

Despite lack of GHG regulation, thermal oilsands operators test variety of carbon capture technologies

By Maurice Smith

▲ JURY STILL OUT

Some in situ oilsands producers are piloting different CO_2 capture technologies for possible future commercial application to slow the industry's growing greenhouse gas emissions.

Producers of bitumen in situ have many advantages over oilsands open-pit mining operators. With a relatively small surface footprint—mainly consisting of wellheads, pipes and associated steam-producing and treatment facilities—they avoid the representations of a scarred landscape and massive tailings ponds commonly associated with surface mines.

But they have an Achilles' heel—as CO_2-intensive as mining operations are, thermal in situ operations are even bigger emitters of gases associated with climate change, and as they approach production levels rivalling mining operations, they play an increasingly dominant role in an industry that already represents Canada's fastest growing source of greenhouse gas (GHG) emissions.

While emitting GHGs to the atmosphere comes at almost no cost to companies operating in Canada today, some of those companies are actively preparing for the day when a cost could be put on their emissions, either via a price on carbon or by regulation. (Alberta has pledged to be sequestering 30 megatonnes of CO_2 per year by 2020 as part of its plan to slow its rapid growth in CO_2 emissions—a commitment out of reach without some kind of regulatory or carbon price provision.) A handful of companies promoting very different technologies to capture that carbon are piloting their methods in hopes of breaking into the oilsands market.

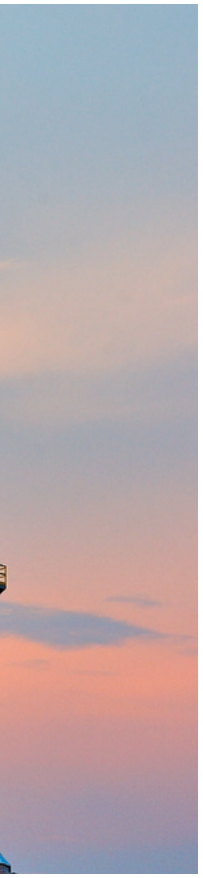
They range from Connecticut-based international gas separation specialist Praxair, Inc., to small technology start-ups like Quebec City's CO_2 Solutions Inc., Regina's HTC Purenergy Inc. and Burnaby, B.C.–based Inventys Thermal Technologies, Inc. Each is working with oilsands majors to advance their technologies in hopes of winning a big piece of the pie if and when regulation kicks in. While previous studies have pegged the cost of CO_2 capture anywhere in the $100-to-$230-per-tonne range, some companies suggest the cost could drop as low as $20 per tonne if the technologies work as anticipated.

Cost is not the only barrier to the technology—the lack of conventional oilfields that could benefit from CO_2 injection for enhanced oil recovery (EOR) or deep saline aquifers in which to sequester CO_2 in the oilsands region around Fort McMurray leave few options to dispense with the CO_2, short of the costly option of building a CO_2 pipeline hundreds of kilometres south, where oilfields and aquifers are plentiful.

Companies are exploring creative ways to get around that problem as well. HTC Purenergy is working with Husky Energy Inc. to capture CO_2 at that company's heavy oil fields in Saskatchewan, where the steam assisted gravity drainage (SAGD) production method most commonly associated with the oilsands is also used. There, the captured carbon can be readily injected into the reservoirs to enhance recovery, with virtually no transportation cost to deal with.

And Cenovus Energy Inc. is among those investigating co-injection of CO_2 into bitumen deposits to enhance oilsands recovery. It is conducting a small scale CO_2 co-injection pilot project. While CO_2 flooding is a proven EOR technique in light oil, it has not been proven in the oilsands. However, if successful, it could provide a much-needed market for CO_2 in the oilsands region. "We are conducting a test to gather more information on how CO_2 interacts with bitumen in a thermal environment.

PHOTO: CENOVUS ENERGY INC.



However, we're still in the early stages and I'm not able to provide any more details," says Jessica Wilkinson, Cenovus's media relations adviser.

PRE-COMBUSTION SOLUTION

One source of CO_2 is Praxair's oxy-fuel combustion technology, which dates back several decades in other industries. By combusting the fuel with oxygen, the flue gas contains high concentrations of CO_2 that are relatively easy to separate. It is the only technology under trial that applies its process primarily pre-combustion, rather than attempting to separate the CO_2 out of the flue gas stream after combustion.

In situ oilsands operators typically combust natural gas—in once-through steam generators (OTSGs)—to create the large quantities of steam required to inject into bitumen deposits to make the bitumen flow. The resulting flue gas typically consists of only about eight per cent CO_2, too diluted to be of any use in enhanced oil recovery or to sequester underground. But by combusting the natural gas in pure oxygen rather than air, Praxair can create the required pure stream of CO_2 by cooling the flue gas and separating the CO_2.

But the process does require some modifications to the boiler, which is being tested as part of an industry- and government-funded pilot project taking place this summer at Cenovus's Christina Lake SAGD facility.

A design and cost estimate for a commercial-scale OTSG boiler with built-in carbon capture, purification and compression technology has already been completed. Phase 2, now underway, will test the reliability, efficiency and cost-effectiveness of an OTSG boiler, equipped with oxy-fuel technology.

The first phase calculated costs in the range of $125–$150 per tonne of CO_2 captured, not including compression and transportation, says Candice Paton, Cenovus energy management and environment engineer. She says the oxy-fuel combustion systems would be able to capture about 99 per cent of CO_2 emitted.

"If it is successful, it has the potential to significantly reduce the cost associated with carbon capture, so we want to make sure we can prove this technology in the SAGD environment with the type of steam generators that Cenovus and other operators use."

One of the biggest advantages of oxy-fuel technology is that it is proven, albeit in different applications, says Mike St. James, Praxair manager of business development, noting it has been used in the steel and glass industries for several decades. "The real test isn't that the combustion process works, it is that the furnace can be modified appropriately and economically to make this process work. We have a couple of schemes that we are looking at and we are testing one of them with this test run with Cenovus."

According to St. James, there are two main components to retrofitting the OTSG: preventing anything but oxygen and fuel from entering the furnace—air is mostly nitrogen and "nitrogen makes carbon capture in furnaces much harder," he says—and installing flue gas recirculation to make up for the reduced flue gas flow in the boiler that results when nitrogen is removed.

For the trial, 99.9 per cent pure liquid oxygen will be trucked to the site, though on-site oxygen production would be used in a commercial operation. "Cryogenic air separation is a 100-year-old technology. It basically involves cooling air down to around the minus-200-[degree-Celsius] range, so that you can separate liquid oxygen from the nitrogen," St. James says.

He estimates the boiler retrofit can be completed for a single-digit percentage of the cost of the furnace itself. "The real cost of this technology is the capital required to purify oxygen, and then all the capital required to do something with the CO_2. The incremental energy consumption to operate all of the facilities could be up to 10 per cent of the SAGD facility's overall energy use.

"To put it into context from an industry perspective, at $100-per-tonne capture cost, for the amount of CO_2 a SAGD plant is producing, [it] would amount to about a $5-per-barrel bitumen cost. Part of the testing here is to determine whether capture costs will be $70 or $100 or $150 per tonne."

While a cost "north of $100 a tonne" of CO_2 captured sounds high, St. James notes "there are potential markets at this price point; one of our tasks as an industry would be to grow this market."

HEAVY OIL APPLICATION

Positioning its technology atop a reservoir that can benefit from the injection of CO_2 is what HTC Purenergy is trialling in an innovative use of its amine-based post-combustion separation technology with Husky Energy. In July 2012, the company announced a $10-million CO_2 capture demonstration project (with $2.9 million from the Alberta government's Climate Change and Emissions Management Corporation, or CCEMC) at Husky's Lashburn, Sask., heavy oil field that will see CO_2 transported a short distance to an existing compression facility and injected into a partially depleted reservoir.

Husky has applied a cookie-cutter approach in quietly building small SAGD projects to produce heavy oil that are capable of extracting up to 50 per cent of oil in place, many times the recovery rates of cold heavy oil production.

The 35-tonne-per-day field pilot follows on the heels of a front-end engineering design (FEED) study for Devon's Jackfish SAGD facility to demonstrate HTC's modular approach. Modelling the separation of 1,000 tonnes of CO_2 per day from three OTSGs, targeting 90 per cent recovery, the study found costs would be under $70 per tonne of CO_2 captured. Conducted with $315,000 in CCEMC funding, the FEED study calculated capital costs at $83 million, or $37 per tonne of carbon captured. Operating costs would add another $30 per tonne.

Like other CO_2 capture technology companies, HTC has shifted from a focus on an expectation of GHG regulations to one responding to profitable uses for CO_2, such as for EOR, CO_2 hydraulic fracturing and as a feedstock in industrial processes. It set up subsidiary HTC CO_2 Systems Corp. over a year ago for that purpose.

Among other initiatives, the company examined the possibility of capturing and pipelining CO_2 from the Graymont Exshaw limestone plant near Canmore, Alta., to be used for EOR in the Turner Valley area south of Calgary, which has drawn interest from several oil producers in the area

The company's pre-engineered, modular system—which it refers to as the world's first such unit—provides post-combustion CO_2 capture customizable to the site requirements of various industrial emitters.

Working with partner companies and research institutions, such as U.K.-based Doosan Power Systems and the University ▶

of Regina, HTC says it has brought costs down in part by better management of the solvent system and utilization of heat energy, and by reducing the amount of solvents that need to be added (makeup) due to degradation.

While the basic amine process isn't new, HTC says its many improvements bring costs down. "Our Thermo Kinetics Optimization is based on utilizing customized thermo-kinetic solvents and innovative configurations, and optimum operation of the plant," says Ahmed Aboudheir, HTC chief technology officer and adjunct professor at the University of Regina engineering department.

"We arrive on a smaller-sized, more efficient plant, with less circulation rate and minimum operating costs in terms of steam and other utilities, like the cooling water and so on. And with a modular approach we have a standard design. That means we can reduce the engineering time and use standard design components, and by doing the fabrication inside the shop, we have a higher level of quality control and much greater efficiency versus field labour."

Its proprietary Solvent Management Reclaimer System is capable of reclaiming single, mixed and formulated solvents at lower cost and with a higher recovery rate for solvent than competing products, the company says. Solvents are the lifeblood of modern amine-based CO_2 capture and acid gas treatment systems, the company says, and the reclaimer unit is needed to remove degradation products and particles suspended in the solvents.

HTC uses the analogy of reclaimers acting as the kidneys of the CO_2 capture units to filter the chemical solvents and restore their absorption efficiencies. If impurities are not removed on a predetermined basis, the solvent will quickly degrade, reducing the acid-gases absorption capacity of the solvent and the overall efficiency of the system, which in turn will increase the operating cost.

As it embarks on its pilot with Husky, HTC hopes to reduce costs further by adding heat integration. "Whenever you introduce a process such as CO_2 capture, there is going to be a certain energy penalty involved, often around 15–20 per cent of the plant's energy requirement. So the secret to more efficient CO_2 capture is, can you reduce the amount of heat that is required to do the stripping process, and the amount of energy to run the pumps and blowers and everything else that makes that plant run?" says Jeff Allison, senior vice-president and chief financial officer.

To put it into context from an industry perspective, at $100-per-tonne capture cost, for the amount of CO_2 a SAGD plant is producing, [it] would amount to about a $5-per-barrel bitumen cost.

— Mike St. James, manager, business development, Praxair, Inc.

The fact the technology is established—a similar system was selected for use at Saskatchewan's Boundary Dam CO_2 separation facility—shows there is little risk to its use, adds Allison. "There are a lot of boutique technologies around," he notes, though few have been proven out on a large scale. "There are always people with new ideas on CO_2 capture. But we have a commercial technology that is ready to go and ready to build, and it has been implemented for many years worldwide."

BIOTECHNOLOGICAL INNOVATION

Quebec's CO_2 Solutions, meanwhile, believes its technology can separate CO_2 from flue gas significantly cheaper than any standard chemical absorption process, which typically uses a monoethanolamine (MEA) solvent. "By using our enzyme, we can use other solvents that are much less energy-intensive or require less energy for regeneration. Our benchmark is we are going to be 30–40 per cent less costly than the MEA approach," says Glenn Kelly, chairman of the board of directors.

CO_2 Solutions was selected last October to receive up to $500,000 from CCEMC for a year-long project to optimize its technology for capture of CO_2 from oilsands production. And in May, CO_2 Solutions hosted Prime Minister Stephen Harper for the announcement of an award of $4.7 million from the ecoENERGY Innovation Initiative toward a 2.5-year, $7.5-million project, which will see the company's technology customized and then tested at large-bench scale, followed by pilot-scale testing in the oilsands.

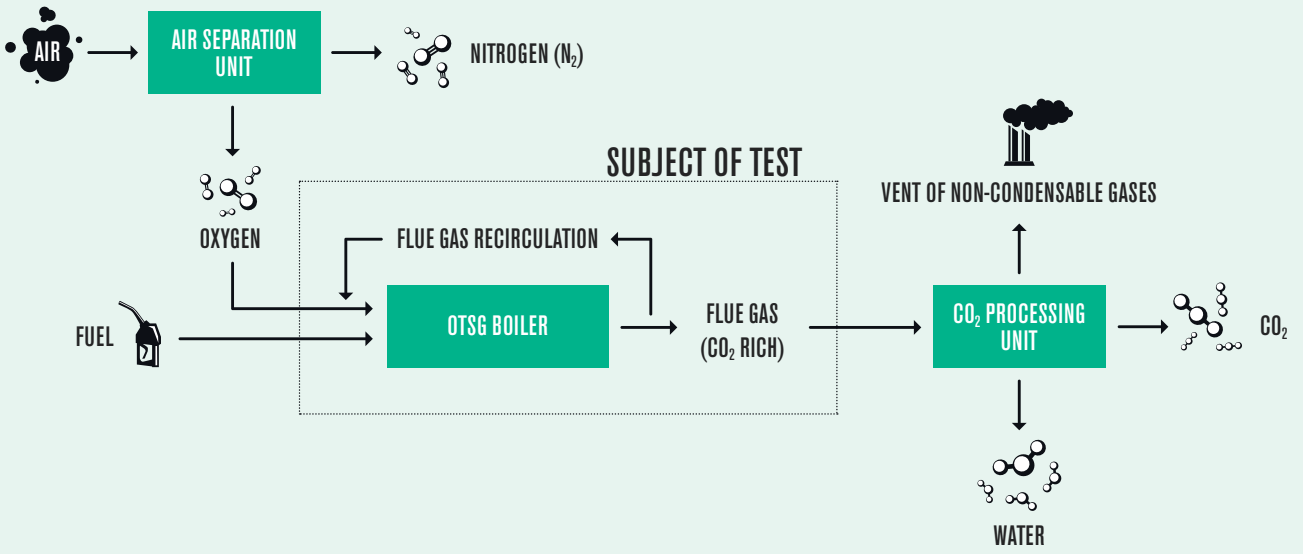
"In 2013 we will be choosing the best process configuration for oilsands flue gas application, which will then be tested in a large-bench unit that is already built and is in an indoor facility in Europe. The subsequent phases in 2014 and the first half of 2015 are to take our learnings from that and design and build a pilot with approximately 30 times the capacity of the large-bench, and test it in situ in Alberta," Kelly says.

The company is working with a large oilsands producer for the field pilot, which it could not yet name. CO_2 Solutions has an extensive patent portfolio covering the use of carbonic anhydrase (CA), or analogues thereof, for the efficient post-combustion capture of CO_2 with low-energy aqueous solvents. In a packed tower scrubbing system, the technology has the potential to substantially improve CO_2 capture efficiency with low-energy solvents (see "An Industrial Lung?," *New Technology Magazine*, December 2011).

CO_2 Solutions has teamed with Procede Group B.V. of the Netherlands, which has extensive carbon capture–process expertise, as an engineering partner where the bench testing will take place. It has also partnered with Codexis, Inc. of Redwood City, Calif., to assist in improving the stability of CA enzymes for harsh industrial conditions and to further pilot and demonstrate the technology. Codexis, a leader in developing and manufacturing "super enzymes" that gained success in genetically modifying enzymes for pharmaceutical production, is genetically engineering CO_2 Solutions' CA to survive at higher temperatures.

Originating from research at Quebec's Université Laval conducted in the 1990s, CO_2 Solutions's technology exploits the capabilities of CA, a naturally occurring enzyme produced by humans and other living things to manage CO_2. In the body, CO_2 is first converted to bicarbonate, then transported to the lungs, where it is transformed back to CO_2, a process assisted by CA. The potent biocatalyst, however, was initially far too costly to obtain, at about $250,000 per gram a decade ago. Through bio-engineering and large-scale production, that cost is now forecast at under $250 per killogram.

In March, CO_2 Solutions announced it had signed a deal with Statoil to provide certain project data and reports, related to the pre-pilot phase of its oilsands project, to the Norwegian-based international energy



SOURCE: PRAXAIR INC.

company, a leader in carbon capture and storage technology development. Statoil was the first company in the world to implement carbon capture and storage on a commercial basis in its Sleipner gas field, where more than 12 million tonnes of CO_2 from treated natural gas has been stored below the North Sea bed since 1996.

CHANGING THE EQUATION

Though not currently testing its technology in the oilsands, Inventys has worked with Suncor, which invested an undisclosed sum to help advance the technology, and is performing preliminary conceptual design of a pilot plant with a major heavy oil producer for CO_2 EOR.

In the meantime, it is proceeding with a carbon capture project with Nova Chemicals Corporation at Joffre, near Red Deer, Alta., that has one major advantage: a ready market for CO_2. Inventys intends to supply CO_2, captured from a natural gas steam boiler, to Penn West Petroleum Ltd., which has been using CO_2 for an EOR flood for 30 years.

In July 2012, Inventys was awarded $3 million in CCEMC funding for the $6-million project, to be installed in the spring of 2014. Assuming a 90 per cent capture rate and taking into account the energy penalty to separate, compress and ship the CO_2, it is estimated the project will sequester one megatonne of CO_2 over the next decade.

The project will be closely watched by oilsands producers, since Inventys estimates it could significantly undercut costs of other methods. Based on modelling, its own testing and a third-party engineering firm's evaluation, it estimates a CO_2 capture cost as low as $20 per tonne. Compression could add another $10 or $30 to the cost before transportation is factored in.

Inventys changed the structure of the CO_2 adsorbent it uses and applied a capital- and energy-efficient rotary adsorption technology to cut costs significantly. Brett Henkel, Inventys's co-founder and vice-president of operations, calls the company's VeloxoTherm process "a completely different technology [compared to the conventional solvent process] using a solid sorbent that has the potential to be a step-change in cost."

VeloxoTherm uses a novel continuous rotary adsorption technology in which a large wheel made of adsorbent turns about one revolution per minute. On one side of the wheel, the spokes collect CO_2 while allowing other gases such as nitrogen and water vapour to pass through. On the other side, the spokes comes into contact with counter-current steam that releases the CO_2. The structured adsorbent can recover and store thermal energy evolved during adsorption and reuse the energy during regeneration, ensuring a minimum of energy is required for regeneration (see "Back to the Oil Age," *New Technology Magazine*, January/February 2012).

"It's not proven yet at scale—that's why we are doing demonstrations to prove that, but the potential for the technology to be that cost-effective is there," says Henkel.

Inventys will have a one-tonne-per-day CO_2 capture demonstration with all the features of a full plant operating in its lab by September, he says, and has another pilot plant scheduled for the field with an undisclosed partner at 10 tonnes per day. The Joffre pilot is 50 tonnes per day.

If Inventys proves out the technology and hits $20 per tonne, "maybe that will change the equation," for CO_2 EOR in western Canada, which has been slow to adopt the EOR technique, Henkel says. "We are pretty confident that the CO_2 EOR market is going to be there, it's just a matter of time. As for carbon capture and storage, it depends on who you talk to whether that is actually going to be a market or not. Maybe our low cost will change that equation, too." ■

▲ EMISSION REDUCTION
This flow diagram shows the application of Praxair's oxy-fuel process applied to a once-through steam generator used to create steam for thermal oilsands production. By combusting natural gas in a pure stream of oxygen rather than air, the process produces a concentrated stream of CO_2.

Monetizing Nuisance Gas

Start-up company leverages utility gas lines to capture and utilize vented and flared gas

▲ GAS TO GO
GO Technologies' M160 GO Tech skid unit can capture natural gas normally flared or vented from the wellhead for sale or redistribution elsewhere.

Many of the heavy oil wells in east-central Alberta and bordering the west-central Saskatchewan region produce excess solution gas that is most easily dealt with by flaring or venting it into the atmosphere. Some produce so much that they are required to be shut in until the gas can be dealt with in some other way. Meanwhile, companies are spending good money on propane at many other wellheads to maintain production.

A start-up Lloydminster, Alta.–area company believes it has a unique solution to both these challenges—one that is already partly in the ground. The company asked why existing low-pressure utility gas lines couldn't be used to conserve the otherwise wasted gas—to either allow purchase of the gas by the utility or to use the lines to take the gas from areas where it is a burden to areas in need of the gas.

In answer to that question, GO Technologies Ltd. developed a proprietary turnkey solution that allows the excess gas to be metered, analyzed and odorized at the wellhead and fed at the pressures required by utilities for their low-pressure dry gas residential lines. The portable skid units provide producers the ability to conserve previously vented and flared gas by selling it into the utility lines, or using the lines to supply gas to other wells that do not produce their own useable gas, says Scott Pratt, GO Technologies electrical manager, who founded the company with president Greg O'Hare.

Companies often install high-pressure tie-ins when excess gas warrants it, he says, but that can be a costly solution, in part because many of the wells do not produce excess gas for extended periods. "So you have wasted infrastructure. That's where we came up with an affordable, low-pressure solution.

"This skid is four feet by seven feet, completely run off a SCADA [supervisory control and data acquisition] system and solar [with backup battery] power, so you can set it down on any existing lease that you have and we tie in—and that's it. You don't have any lease costs or other costs, and if that well loses gas [production], we can drive it to the next one that has gas."

The GO Tech M160 is equipped with an Envent Moisture Analyzer with the AutoCalibration feature and a DynaPak Sampler for gas analysis. The unit can be used in combination with one or several compression units, and with the current dryer system on small compressor packages, dry speck gas can be easily obtained, says the company. Each unit is built to Pipeline Facilities Code B31-3 and comes with a full quality-control package.

The company essentially acts as a go-between for the producer and the utility, facilitating the connections and removing the risks for both sides. "We are putting all the fail safes in place. For instance, it has a fail-safe valve, so if there is any moisture in the line above the limit they want on that line, it shuts it down. We take dew point samples, we do gas analysis samples, we do everything necessary to maintain what's needed for a low-pressure system," Pratt says.

"Our tie-in costs for a low-pressure line are a fraction of what it costs to put a high-pressure system in, and any number of wells can be hooked in to this unit. If it's not cost-effective for one well and you have another well down the road, you can tie them both in to the same unit," he adds. "Another thing we learned in talking to producers is, being able to have that vent gas cracked wide open, that's going to get you more production out of that well."

In the case of a shut-in oil well, "it's a no-brainer," says Pratt, calculating nearly $2 million annually in lost combined oil and gas sales that could be achieved with the GO Technologies system in place.

In another scenario the company presents where excess casing vent gas is being produced by multiple wells, four wells are tied in to one unit, providing

PHOTO: GO TECHNOLOGIES LTD.

1.5 thousand cubic feet each, representing over $700 per day, or more than $21,000 per month, in gas sales otherwise lost to atmosphere.

"That's quite a bit of money being lost. In this scenario, we took the gas and instead of just selling it to the low-pressure distribution company, we pull that gas out somewhere down the line and take other wells off propane."

Propane is sometimes used for operating skid drives and burner systems for heavy oil production. In this scenario, seven oil wells—each consuming about $400 per day, or $12,000 per month, in propane—could be supplied with far cheaper natural gas instead, for an annual combined savings of almost $1 million.

GO Technologies spent several months negotiating agreements with gas utilities in the Lloydminster region before promoting the service widely. Pratt says the utilities saw the benefits of signing up in securing new markets and expanding their infrastructure. While Saskatchewan is a little behind, Alberta is already "very good at having a low-pressure grid throughout the province," he says.

While getting the deals in place, GO Technologies piloted two units on previously shut-in heavy oil wells operated by Husky Energy Inc., in which the gas was sold to the County of Vermilion River Gas Utility. "There were no issues with the units and their payout was less than a week."

While great strides have been made in the last two decades to reduce venting and flaring in western Canada, levels have been rising again in recent years, due to both increased oil production levels and low natural gas prices, which make it less cost-effective to conserve it.

According to the Alberta Energy Regulator, the combined volume of flared and vented solution gas in Alberta in 2011 totalled 27.86 billion cubic feet, or 76 million cubic feet per day, an increase of about 22 per cent from 2010. Flaring from oil batteries outside the oilsands regions totalled 13.76 billion cubic feet in 2011—an increase of 72 per cent from the previous year, while venting from conventional oil batteries totalled 3.98 billion cubic feet—up 11 per cent from 2010.

"There's a lot of vent and flare gas going into [the] atmosphere—not only that, but it is a lot of revenue being lost. It is definitely an issue," says Pratt.

■ ***Maurice Smith***

▶ Birds Getting Laser Treatments

Deterrents anything but ho-hum

PHOTO: CANADIAN NATURAL RESOURCES LIMITED

▲ KEEPING WATCH
Radar, laser systems, loud sound effects and animated predator effigies are among the devices being used in increasingly sophisticated efforts to deter birds from oilsands operations.

Zombie-movie screams on a long, black, bone-chilling night in northern Alberta would probably scare anyone away, and might be the last thing one would expect to hear in that setting.

Green lasers stabbing the frigid night might also come as a surprise, but both methods are being used by oilsands companies to frighten away not humans but birds from their tempting-but-toxic tailings ponds.

Imperial Oil Limited has had lasers and long-range acoustical devices (LRAD) that use a variety of noises—including those screams, barking dogs and birds screeching warnings—integrated into a detection and tracking system at its Kearl oilsands project, even before the project started up in April.

Along with other deterrents, Canadian Natural Resources Limited says it has been using lasers at its tailings pond since the Horizon mine's start-up in 2009, and plans to expand its LRAD system.

Canadian Natural's laser system spreads out a static pattern of green laser light across the pond at its Horizon mine, creating an eerie effect "so that the birds coming in are very surprised to see this large, shimmering surface of the tailings pond and they'll try to avoid that because that is something that ▶

they don't like," says Calvin Duane, Canadian Natural's manager of environment.

"It's deemed to be one of the more effective devices," says Canadian Natural public affairs manager Peter Kinnear.

Syncrude Canada Ltd. is not taking any chances, either of birds landing on its ponds again or in the effectiveness of its deterrents. In 2008, 1,600 ducks landed on its tailings pond and drowned. Two years later, another 230 ducks landed and had to be euthanized after being coated in bitumen. The company's reputation, and that of the entire industry, was tarnished around the world.

So Syncrude, like the other oilsands mine operators, is now employing a raft of state-of-the-art bird deterrents, but is still testing lasers for their effectiveness.

The company wants to evaluate what effect they have before simply throwing technology at the problem, says Mark Polak, a Syncrude research associate who conducted the study. There is limited data on whether they actually work, he says.

"We don't want to go to the trouble of maintaining these devices if they're completely useless—and you have to be careful that you're not actually attracting the birds," says Polak. "Birds can be attracted to bright lights."

Syncrude's search of literature on the use of lasers as bird deterrents found they can be effective, but only under poor-visibility conditions. On nice, bright, sunny days they won't have much effect, but could be used to supplement other deterrents, especially at night, when the visual deterrents are not going to be as effective, he says.

According to scientific literature, the lasers' effectiveness depends on locale, time of year and even the species of bird, but existing study results were inconsistent. Syncrude wanted to know if they would work at its sites during migration season—when birds are most likely to land on tailings ponds—and with the species of birds typical to the area, so Polak conducted an empirical study using Accipiter Radar Technologies Inc.'s expertise to design the study protocol and help interpret the results.

All scientific studies showing successful laser-based bird deterrence only used red- and green-coloured devices. There's no evidence that any other colours would work and commercially available hand-held laser deterrents only come in those colours, Polak told an oilsands conference in Calgary.

He said that during fall migration, between August 16 and Oct. 21, 2011, two people using regular and night-vision binoculars scanned seven small, freshwater ponds near Syncrude's Mildred Lake settling pond, over about 10 kilometres, counting the birds and noting their species.

> *"...The birds coming in are very surprised to see this large, shimmering surface of the tailings pond and they'll try to avoid that because that is something that they don't like."*
>
> — Calvin Duane, manager of environment, Canadian Natural Resources Limited

While one person continued to observe the birds with night-vision equipment, the other did a slow sweep of the pond with a hand-held laser, pointed about one to two metres above its surface, careful not to drive the birds into the tailings pond. The researchers would then turn the laser off, record the results, wait a minute and again count the birds that remained. This was done twice per visit.

Each pond was visited four or five times per night, altering the lasers systematically from green to red. Researchers categorized the birds as "dispersed" only if they left the pond and surrounding area. Swimming away a little didn't count, he says.

There were 1,301 tests conducted on at least 404 birds. The green laser worked better than the red. Green dispersed 96 per cent of sandhill cranes and 82 per cent of Canada geese. Red lasers dispersed 66 per cent of sandhill cranes and 64 per cent of Canada geese.

Neither colour had an effect on ducks. Some ducks dove and some paddled into weeds, but they did not fly away.

It's difficult to say why birds react differently to one colour than another, and even between species, says Robert Beason, an ornithologist with Niagara, Ont.–headquartered Accipiter Radar Technologies, who provided birding expertise to the study.

Birds' eyes are not the same as humans', he says. "What we see is not necessarily the same as what birds see. You have to always keep that in mind."

Beason says lasers are also used to scare large groups of birds away from golf courses, parks and lakes, but only in France are they used at airports due to eye-safety concerns.

According to Polak, a human would have to look at the laser for 10 seconds without blinking to do damage.

Beason says the beams are safe for birds because exposure to them is very brief. "I know of people who have shined the lasers directly in birds' eyes and lasers of these classes caused no damage. [There have been some] studies on the retina. No problem. I've seen other studies where they've used high-powered lasers, to the point the birds' feathers were starting to smoke, and the birds ignored it; it didn't bother them. They kind of twisted a little bit. There was a bit of damage to the retinas, but not that you would see in humans."

Syncrude's researchers did not see any signs of habituation—a common problem in outwitting birds—to the lasers. If they left the pond, they did not return that night, says Polak. Others' research on lasers, however, did find that birds that left the area returned within 20 minutes, he says.

An Accipiter Bird Protection Radar System recently installed at Syncrude facilities is the largest and most sophisticated radar-based bird protection system ever deployed, according to Accipiter. To cover the many tailings ponds over a large area, the system integrates numerous radar units and hundreds of wirelessly controlled, radar-activated bird deterrent devices that can all be monitored and controlled from a central site.

There are several types of deterrent devices, both on land and floating on the ponds, including high-power acoustic hailing devices, propane cannons, strobe lights and animated predator effigies, the company says. Radar activation allows the deterrents to remain inactive until birds are detected. They are triggered at the ideal distance from the bird for maximum effect. The sophisticated tracking radar measures the location, altitude, speed, direction and size of each bird and can distinguish safe behaviour, such as flying away from or overflying a tailings pond, from risky behaviour such as flying toward the pond while descending.

Now Syncrude is building a prototype that it will integrate with its existing radar systems to collect data and have the lasers come on automatically.

Lynda Harrison

Technology revolutionizes Canada's oil & gas industry

Each year, *New Technology Magazine* conducts a search for the most revolutionary technologies and the individuals who created them.

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403-845-3101 www.mccawsdrilling.com

Mi Casa Rentals Inc.
200, 435 - 4 Ave. S.W. Calgary AB T2P 3A8
403-262-2288 www.micasa-rentals.com

Nabors Canada
2800, 500 - 4 Ave. S.W. Calgary AB T2P 2V6
403-263-6777 www.nabors.com

Newsco International Energy Services Inc.
7000 Railway St. S.E., Calgary AB T2H 3A8
403-243-2331 www.newsco.ca

Noble Drilling (Canada) Ltd.
4 Fl., 10 Fort William Pl. St. John's NL A1C 1K4
709-758-4400 www.noblecorp.com

Norseman Inc.
14545 - 115 Ave. Edmonton AB T5M 3B8
780-451-6828 www.norseman.ca

NorthBasin Energy Services Inc.
200, 604 - 1 St. S.W. Calgary AB T2P 1M7
403-648-8600 www.northbasinenergy.com

Northwell Rentals (Lloydminster) Inc.
9111 - 39 Ave. Edmonton AB T6E 5Y2
780-437-7469

Northwell Rentals (R&M) Inc.
9111 - 39 Ave. Edmonton AB T6E 5Y2
780-437-7469

Pacrim Steel
Box 36063 Calgary AB T3E 7C6
403-234-8228 www.pacrimsteel.com

Parsons Oilfield Services & Supply Inc.
922 - 19 Ave. N.W. Calgary AB T2M 0Z5
403-818-2005

Pason Systems Inc.
6130 - 3 St. S.E. Calgary AB T2H 1K4
403-301-3400 www.pason.com

Patterson - UTI Drilling Canada Limited
720, 734 - 7Ave. S.W. Calgary AB T2P 3P8
403-269-2858 www.patenergy.com

Peloton Computer Enterprises Ltd.
450, 1000 - 7 Ave. S.W. Calgary AB T2P 5L5
403-263-2915 www.peloton.com

Perception Petroleum Corp.
128 Malibu Rd. S.W. Calgary AB T2V 1X7
403-253-7028

Petris Canada
805, 734 - 7 Ave. S.W. Calgary AB T2P 3P8
403-225-4954 www.petris.com

Pinnacle Drilling Fluids Ltd.
Box 20055 Calgary AB T2P 4J2
403-233-2500 www.pinnaclefluids.com

Precision Drilling
800, 525 - 8 Ave. S.W. Calgary AB T2P 1G1
403-716-4500 www.precisiondrilling.com

Precision Drilling Company Limited Partnership
700, 10350 Richmond Ave. Houston TX 77042-4
713-435-6100 www.precisiondrilling.com

Precision Drilling Corporation
800, 525 - 8 Ave. S.W. Calgary AB T2P 1G1
403-716-4500 www.precisiondrilling.com

Predator Drilling Inc.
210 Clearskye Way Red Deer County AB T4E 0A1
403-896-9299

Prinoth Ltd.
6815A - 40 St. S.E. Calgary AB T2C 2W7
403-279-7271 www.prinoth.com

Quintera Drilling LP
Box 1408 Brooks AB T1R 1C3
403-501-3704

Rangeland Energy Services
Box 5098 High River AB T1V 1M3
403-652-3253 www.rangelandinc.com

RBI Canada 2000 Inc.
5677 Burleigh Cres. S.E. Calgary AB T2H 1Z7
403-255-3730 www.rbi-canada.com

Reliance Industrial Products Ltd.
606 - 19 Ave. Nisku AB T9E 7W1
780-955-7115 www.relianceindustrial.com

Rheotech Drilling Fluid Services Inc.
610, 700 - 4 Ave. S.W. Calgary AB T2P 3J4
403-237-8870 www.rheotech.ca

Richfield Equipment Ltd.
Box 314 Okotoks AB T1S 1A6
403-236-0056 www.richfieldequipment.ca

Robbins & Myers Energy Services Canada
3703 - 98 St. Edmonton AB T6E 5N2
780-465-9500 www.rmenergy.com

Rocking Horse Energy Services Inc.
23 Spruce Park Dr. Strathmore AB T1P 1J2
403-324-4224 www.rockinghorseinc.com

Rotary Sales & Service
9516 - 62 Ave. Edmonton AB T6E 0C9
780-434-3621

Savanna Drilling
800, 311 - 6 Ave. S.W. Calgary AB T2P 3H2
403-214-5970 www.savannaenergy.com

Savanna Energy Services Corp.
800, 311 - 6 Ave. S.W. Calgary AB T2P 3H2
403-503-9990 www.savannaenergy.com

Saxon Energy Services Inc.
1700, 700 - 4 Ave. S.W. Calgary AB T2P 3J4
403-716-4150 www.saxonservices.com

Schlumberger, Drilling Tools & Remedial (DTR)
200, 125 - 9 Ave. S.E. Calgary AB T2G 0P6
403-264-6077 www.smith.com

Sentry Pumping Units International
1150, 444 - 5 Ave. S.W. Calgary AB T2P 2T8
403-775-7077 www.sentryinternational.net

Sicotte Drilling Tools Inc.
1101 - 77 Ave. Edmonton AB T6P 1M8
780-440-6700 www.sicottedrillingtools.com

Simmons Edeco Inc.
800, 906 - 12 Ave. S.W. Calgary AB T2R 1K7
403-244-5340 www.simmonsedeco.com

Singletouch Canada Inc.
1300 - 8 St. S.W. Calgary AB T2R 1B2
403-648-3930 www.singletouch.com

Southwest Distribution Ltd.
9691 - 45 Ave. N.W. Edmonton AB T6E 5Z8
780-434-3473

Sphere Drilling Supplies
3112 - 80 Ave. S.E. Calgary AB T2C 1J3
403-720-9333 www.spheredrilling.com

Superior Drilling & Coring
650, 717 - 7Ave. S.W. Calgary AB T2P 0Z3
403-532-8942

Tall Pine Drilling Ltd.
Box 700 Bentley AB T0C 0J0
403-748-2955 www.tallpinedrilling.com

Technicoil Corporation
1100, 250 - 2 St. S.W. Calgary AB T2P 0C1
403-509-0700 www.technicoilcorp.com

Teledrift Canada Inc.
7, 4275 - 78 Ave. S.E. Calgary AB T2C 2Y4
403-203-0840

Tempco Drilling Company Inc.
Box 5543, Stn. A Calgary AB T2H 1X9
403-259-5533

Terracon Geotechnique Ltd.
800, 734 - 7 Ave. S.W. Calgary AB T2P 3P8
403-266-1150 www.terracon.ca

Terracon McKay Ltd.
800, 734 - 7 Ave. S.W. Calgary AB T2P 3P8
403-266-1150 www.terracon.ca

Terroco Drilling Ltd.
4044, 39139 Hwy. 2A Red Deer County AB T4S 2A8
403-343-6236 www.terroco.com

Tervita Corporation
500, 140 - 10 Ave. S.E. Calgary AB T2G 0R1
403-233-7565 www.tervita.com

The Crossing Company Inc.
1807 - 8 St. Nisku AB T9E 7S8
780-955-5051 www.thecrossingcompany.com

The Motor Company
5420 - 53 Ave. S.E. Calgary AB T2C 4R3
403-230-3055 www.themotorcompany.ca

Thor Drilling Ltd.
Ste. B, 2638 - 27 St. S.W. Calgary AB T3E 2G5
403-263-5555

3D Drilling Tools Inc.
8135 Wagner Rd. Edmonton AB T6E 4N6
780-440-1922 www.3Ddrillingtools.ca

Total Energy Services Inc.
2550, 300 - 5 Ave. S.W. Calgary AB T2P 3C4
403-216-3939 www.totalenergy.ca

Tracer Supervision
1110, 340 - 12 Ave. S.W. Calgary AB T2R 1L5
403-261-7097 www.barlon.ca

Tracker Sales & Rentals Ltd.
Box 809 Bowden AB T0M 0K0
403-224-0000 www.trackersalesltd.com

Trendon Bit Service Ltd.
Box 548 Redcliff AB T0J 2P0
403-548-7242 www.trendonbitservice.com

Treo Drilling Services L.P.
R.R. 2 Ponoka AB T4J 1R2
403-783-5720 www.treodrilling.com

Trinidad Drilling LP, Northern Division
1700, 633 - 17 St. Denver CO 80202
720-210-9343

Trinidad Drilling LP, Southern Division
20105 Krahn Rd. Spring TX 77388
713-439-1670 www.trinidaddrilling.com

Trinidad Drilling Ltd.
2500, 700 - 9 Ave. S.W. Calgary AB T2P 3V4
403-265-6525 www.trinidaddrilling.com

Tri-Service Oilfield Manufacturing Ltd.
9545 - 58 Ave. N.W. Edmonton AB T6E 0B8
780-434-9596 www.tsm.ca

Tristar Resource Management Ltd.
800, 815 - 8 Ave. S.W. Calgary AB T2P 3P2
403-262-8595 www.tstar.ca

Tuscany International Drilling Inc.
Unit 1950, 140 - 4 Ave. S.W. Calgary AB T2P 3N3
403-265-8258 www.tuscanydrilling.com

Univar Canada Ltd.
9800 Van Horne Way Richmond BC V6X 1W5
604-273-1441 www.univarcanada.com

Universe Machine Corporation
5545 - 91 St. Edmonton AB T6E 6K4
780-468-5211 www.umcorp.com

Varel Rock Bits Canada Inc.
9926 - 29 Ave. Edmonton AB T6N 1A2
780-435-5706 www.varelintl.com

Viper Rentals & Services Ltd.
10709 - 95 St. High Level AB T0H 1Z0
780-926-3366 www.viperrentals.ca

Walters Oil Tool Machine Ltd.
9924 - 29 Ave. Edmonton AB T6N 1A2
780-462-4744

Wenzel Downhole Tools Ltd.
1000, 717 - 7 Ave. S.W. Calgary AB T2P 0Z3
403-262-3050 www.downhole.com

Western Energy Services Corp.
1700, 215 - 9 Ave. S.W. Calgary AB T2P 1K3
403-984-5916 www.wesc.ca

Westquip Diesel Sales (Alta.) Ltd.
208 Walker Cres. Acheson AB T7X 5A4
780-960-5560 www.westquip.ca

XI Technologies
1700, 734 - 7 Ave. S.W. Calgary AB T2P 3P8
403-517-0111 www.xitechnologies.com

XL Fluid Systems
1800, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-264-1588 www.xlfluids.com

PRODUCTION

Access Waterwells Inc.
Box 7297 Edson AB T7E 1V5
780-723-2242 www.accesswaterwells.com

Accu-Flo Meter Service Ltd.
4028 - 7 St. S.E. Calgary AB T2G 2Y8
403-243-1425 www.accuflo.com

Accurata Inc.
120 MacEwan Park Rise N.W. Calgary AB T3K 4A1
403-295-1637 www.accurata.ca

Adoil Inc.
B11 416 Meridian Rd. S.E. Calgary AB T2A 1X2
403-242-2201 www.adoil.net

Advanced Flow Tech
Unit 5, 6125 - 11 St. S.E. Calgary AB T2H 2L6
403-212-2382 www.afti.ca

Advantage Mud Systems Ltd.
730, 777 - 8 Ave. S.W. Calgary AB T2P 3R5
403-262-1120 www.advantagemud.com

AERO Rental Services
6525 - 67 St. Red Deer AB T4P 1A3
403-340-0800 www.aerorentals.com

ALCO Gas & Oil Production Equipment Ltd.
5203 - 75 St. Edmonton AB T6E 5S5
780-465-9061 www.alcogasoil.com

Alpha Controls & Instrumentation
6, 361 Steelcase Rd. West
Markham ON L3R 3V8
905-477-2133 www.alphacontrols.com

Amos & Co. Ltd.
708, 804 - 3 Ave. S.W. Calgary AB T2P 0G9
403-261-0823

Annugas Compression Consulting Ltd.
3601 - 48 St. Wetaskiwin AB T9A 3N9
780-361-2350 www.annugas.com

Apex Distribution Inc.
550, 407 - 2 St. S.W. Calgary AB T2P 2Y3
403-268-7333 www.apexdistribution.com

Apex Energy Consultants Inc.
2300, 635 - 8 Ave. S.W. Calgary AB T2P 3M3
403-269-9550 www.apexenergy.com

Apex Equipment Ltd.
116, 5726 Burleigh Cres. S.E. Calgary AB T2H 1Z8
403-214-2049 www.apexequipmentltd.com

Apex Oilfield Services (2000) Inc.
910, 734 - 7 Ave. S.W. Calgary AB T2P 3P8
403-257-5152 www.apexoil.ca

API Oilfield Hauling Inc.
R.R. 1 Red Deer AB T4N 5E1
403-309-7400

Aramark Remote Workplace Services Ltd.
9647 - 45 Ave. Edmonton AB T6E 5Z8
780-437-5665 www.aramarkremote.com

Ardy Rigging Ltd.
Box 180 Valleyview AB T0H 3N0
780-524-3459 www.ardyrigging.com

Argus Machine Co. Ltd.
5820 - 97 St. Edmonton AB T6E 3J1
780-434-9451 www.argusmachine.com

Armor Well Servicing Ltd.
10, 24 Cuendet Industrial Way
Red Deer County AB T4S 0J7
780-979-9922

ATECH Application Technology Limited
2927 - 13 Ave. N.W. Calgary AB T2N 1M1
403-261-0005 www.atech.ca

Baker Hughes Canada Company
1000, 401 - 9 Ave. S.W. Calgary AB T2P 3C5
403-537-3400 www.bakerhughes.com

Baron Oilfield Supply
9515 - 108 St. Grande Prairie AB T8V 5R7
780-532-5661 www.baronoilfield.ca

Bell Industries
5317 - 91 St. Edmonton AB T6E 6E2
780-434-4401 www.bellindustries.net

Big Bear Energy Rentals Ltd.
Comp. 7, Site 5, R.R. 1 Sylvan Lake AB T4S 1X6
403-887-2839 www.bigbearenergy.com

Black Diamond Energy Services
2000, 715 - 5 Ave. S.W. Calgary AB T2P 2X6
403-206-4747 www.blackdiamondgroup.com

Black Ink Oilfield Mechanical Inc.
6 Wellhead St. Devon AB T9G 1Z6
780-987-4924 www.black-ink.ca

Black Ridge Consulting & Oilfield Services Ltd.
Box 90 Griffin SK S0C 1G0
306-848-1995

Bonnett's Energy Corp.
65007 Hwy 43, C.O.G.P #1 Grande Prairie AB T8W 5E7
780-513-3400 www.bonnettsenergy.com

Bouchard Well Service Ltd.
459 Aquaduct Dr., Box 1955 Brooks AB T1R 1C7
403-362-4732

Boundary Equipment Co. Ltd.
10740 - 181 St. Edmonton AB T5S 1K8
780-483-3133 www.boundaryequipment.com

Bowie Pumps of Canada Ltd.
9333 - 41 Ave. N.W. Edmonton AB T6E 6R5
780-465-7812 www.bowiepumps.com

Brandette Well Servicing Ltd.
Box 6150 Drayton Valley AB T7A 1R6
780-542-3404 www.brandette.com

Brost Well Servicing
Box 25012 Red Deer AB T4R 2M2
403-314-0434

Brother's Specialized Coatings
6150 - 76 Ave. Edmonton AB T6B 0A6
780-440-2855 www.brotherscoating.com

C.B. Engineering Limited
5040 - 12A St. S.E. Calgary AB T2G 5K9
403-259-6220 www.cbeng.com

Cactus Gas & Oil Operators Ltd.
26 Chinook Dr. S.W. Medicine Hat AB T1A 4B3
403-526-8910

Calfrac Well Services Ltd.
411 - 8 Ave. S.W. Calgary AB T2P 1E3
403-266-6000 www.calfrac.com

Calmena Energy Services Inc.
700, 333 - 7 Ave. S.W. Calgary AB T2P 2Z1
403-225-3879 www.calmena.com

Canadian Nitrogen Services Ltd.
610B McCool St., Box 1909 Crossfield AB T0M 0S0
403-946-0404 www.canadiannitrogen.com

Canadian Wellhead Isolation
34 Industrial Dr. Sylvan Lake AB T4S 1P4
403-340-3356 www.wellheadisolation.com

Canamara - United Supply
8750 - 53 Ave. Edmonton AB T6E 5G2
780-468-4064 www.canamara-united.com

Canyon Technical Services Ltd.
2900, 255 - 5 Ave. S.W. Calgary AB T2P 3G6
403-355-2300 www.canyontech.ca

Carbon Controls Ltd.
Bay 124, 11979 - 40 St. S.E. Calgary AB T2Z 4M3
403-238-9944 www.carboncontrolsltd.com

Carnwood Wireline Service Ltd.
108, 3907 - 98 St. Edmonton AB T6E 6M3
780-434-1122 www.carnwood.com

Cartel Energy Services Inc.
Box 155 Beiseker AB T0M 0G0
403-947-3334 www.cartelenergy.com

Cathedral Energy Services Ltd.
6030 - 3 St. S.E. Calgary AB T2H 1K2
403-265-2560 www.cathedralenergyservices.com

Chad Equipment Ltd.
311 Hwy. 40 East Box 445 Neilburg SK S0M 2C0
306-823-4561

Chemline Plastics Limited
55 Guardsman Rd. Thornhill ON L3T 6L2
905-889-7890 www.chemline.com

Circle T Service & Rental Ltd.
8012 Edgar Industrial Green Red Deer AB T4P 3S2
403-342-6004 www.circletrentals.com

Clariant (Canada) Inc.
950, 717 - 7 Ave. S.W. Calgary AB T2P 0Z3
403-262-7846 www.oil.clariant.com

Classic Oilfield Service Ltd.
5222 - 62 St. Lloydminster AB T9V 2T3
780-875-3276 www.classoil.com

Codeco Energy Group Inc.
2 Fl., 717 - 7 Ave. S.W. Calgary AB T2P 3H6
403-237-7808 www.codecoenergygroup.com

Cofex Ltd.
Box 179, 3428 - 99 St. Edmonton AB T6E 5X5
780-914-4010

Coltek Energy Services Ltd.
11474 - 96 Ave. Grande Prairie AB T8V 5M4
780-538-9878 www.coltekenergy.com

Commercial Truck Equipment Co.
9111 - 41 Ave. Edmonton AB T6E 6M5
780-468-5151 www.dancoequipment.com

Computer Modelling Group Ltd.
200, 1824 Crowchild Trail N.W. Calgary AB T2M 3Y7
403-531-1300 www.cmgl.ca

ConleyMAX Inc.
850, 396 - 11 Ave. S.W. C AB T2R 0C5
403-476-7011 www.conleymax.com

Conn Pumps
138, 2137 - 33 Ave. S.W. Calgary AB T2T 1Z7
403-262-5151 www.connpumps.com

Cool Air A/C Service & Repair
Box 370 Avonlea SK S0H 0C0
306-868-2291

Couturier Oilfield Anchors Ltd.
50119 R.R.75, Lot 206, Box 5039
Drayton Valley AB T7A 1R3
780-542-6358 www.couturieranchors.com

CTE Industries Ltd.
2451 - 76 Ave. N.W. Edmonton AB T6P 1P6
780-485-8799 www.cteltd.com

C-Tech Design & Manufacturing
3201 - 84 Ave. Edmonton AB T6P 1K1
780-464-3800 www.ctechenergy.com

C-TECH Oilwell Technologies Inc.
3201 - 84 Ave. Edmonton AB T6P 1K1
780-464-3800 www.ctechenergy.com

Cummins Western Canada
18452 - 96 Ave. Surrey BC V4N 3P8
604-882-5000 www.westerncanada.cummins.com

CWC Well Services Corp.
6763 - 76 St. Red Deer AB T4P 3R7
403-341-3933 www.cwcwellservices.com

D & D Oilfield Rentals Corp.
Box 1197 Redcliff AB T0J 2P0
403-548-2700 www.ddoil.net

Daniel Industries Canada Inc.
4215 - 72 Ave. S.E. Calgary AB T2C 2G5
403-279-1879 www.daniel.com

Davis Controls Limited
2200 Bristol Circle Oakville ON L6H 5R3
905-829-2000 www.daviscontrols.com

Delta-P Test Corp.
300, 85 Shawville Blvd. S.E., Box 18039
Calgary AB T2Y 3W0
403-254-5445 www.delta-p.net

Demand Data Services Inc.
520, 736 - 6 Ave. S.W. Calgary AB T2P 3T7
403-263-3023 www.demanddataservices.com

Dewitz Enterprises
Box 2014 Whitecourt AB T7S 1P7
780-778-6232

Diamond Coiled Tubing
1521 North Service Rd. West Swift Current SK S9H 3S9
306-778-6682 www.diamondenergy.ca

Diamond Energy Services
1521 North Service Rd. West Swift Current SK S9H 3S9
306-778-6682 www.diamondenergy.ca

DPS Microbial Solutions
312 - 3 St., Box 116 Frobisher SK S0C 0Y0
306-486-2110 www.dpsmicrobial.com

Dril-x-Fluids Inc.
800, 839 - 5 Ave. S.W. Calgary AB T2P 3C8
403-444-1517 www.dril-x.com

DrSCADA Automation
160, 32 Westwinds Cres. N.E. Calgary AB T3J 5L3
403-264-5937 www.drscada.com

Eagle Well Servicing
8113 - 49 Ave. Close Red Deer AB T4P 2V5
403-346-7789 www.eaglerigs.com

Electric Motor Service Limited
8835 - 60 Ave. Edmonton AB T6E 6L9
780-496-9300 www.emsl.ca

Endress + Hauser Canada Ltd.
1075 Sutton Dr. Burlington ON L7L 5Z8
905-681-9292 www.ca.endress.com

Enerchem International Inc.
3900, 205 - 5 Ave. S.W. Calgary AB T2P 2V7
403-266-1985 www.enerchem.com

Enerflex Ltd.
904, 1331 Macleod Trail S.E. Calgary AB T2G 0K3
403-387-6377 www.enerflex.com

Entero Corporation
500, 1040 - 7 Ave. S.W. Calgary AB T2P 3G9
403-261-1820 www.entero.com

ERS Environmental Refuelling Systems Inc.
208, 10464 Mayfield Rd. Edmonton AB T5P 4P4
780-444-4104 www.envirofuel.ca

Essential Coil & Stimulation Services - North
7775 Edgar Industrial Way Red Deer AB T4P 3R2
403-347-6717 www.essentialenergy.ca

Essential Energy Services Ltd.
1100, 250 - 2 St. S.W. Calgary AB T2P 0C1
403-263-6778 www.essentialenergy.ca

Essential Well Service - North
Box 6028 Drayton Valley AB T7A 1R6
780-621-0654 www.essentialenergy.ca

Essential Well Service - South
1402 Brier Park Cres. N.W. Medicine Hat AB T1C 1T9
403-527-6235 www.essentialenergy.ca

EV Canada Inc.
890, 736 - 8 Ave S.W. Calgary, AB T2P 1HA
403-263-6144 www.evcam.com

Ex-Cel Well Servicing Ltd.
420 Boscuruis Ave., Box 775 Oxbow SK S0C 2B0
306-483-2281

Extreme Telematics Corp.
111, 1144 - 29 Ave. N.E. Calgary AB T2E 7P1
403-290-6300 www.etcorp.ca

Flexpipe Systems
3501 - 54 Ave. S.E. Calgary AB T2C 0A9
403-503-0548 www.flexpipesystems.com

Fluid Energy Group Ltd
104, 214 – 11 Ave. S.E. Calgary, AB T2G 0X8
403-463-5843 www.fluidenergygroup.com

FMC Technologies Company
6703 - 68 Ave. N.W. Edmonton AB T6B 3E3
780-468-9231 www.fmctechnologies.com/SurfaceWellhead.aspx

FMC Technologies Company (Subsea Systems)
44-46 Dundee Ave. Mount Pearl NL A1N 4R7
709-752-6200 www.fmctechnologies.com

4-Way Equipment Rentals
8430 - 24 St. Edmonton AB T6P 1X8
780-464-4929 www.4-way.com

Frac Rite Environmental Ltd.
2, 4416 - 5 St. N.E. Calgary AB T2E 7C3
403-265-5533 www.fracrite.ca

Frank Henry Equipment (1987) Ltd.
9810 - 60 Ave. Edmonton AB T6E 0C5
780-434-8778 www.frank-henry.com

Frontier Power Products Ltd.
7983 Progress Way Delta BC V4G 1A3
604-946-5531 www.frontierpower.com

Galvanic Applied Sciences, Inc.
7000 Fisher Rd. S.E. Calgary AB T2H 0W3
403-252-8470 www.galvanic.com

General Well Servicing Ltd.
Box 700 Carnduff SK S0C 0S0
306-482-3244

Geospace Technologies Canada, Inc.
2735 - 37 Ave. N.E. Calgary AB T1Y 5R8
403-250-9600 www.geospace.com

Global Flow Inc.
Bay 2, 2315 - 30 Ave. N.E. Calgary AB T2E 7C7
403-219-7373 www.globalflowinc.com

Global Steel Ltd.
401, 888 - 4 Ave. S.W. Calgary AB T2P 0V2
403-237-8108 www.globalsteel.ca

Global Well Servicing Ltd.
Box 7745 Drayton Valley AB T7A 1S8
780-515-9885 www.globalwellservicing.com

GPM Sales & Service Inc.
4216 - 76 Ave. Edmonton AB T6B 2H8
780-432-6957 www.wwwunifiedvalve.com

GS Hitech Controls Inc.
6173 - 6 St. S.E. Calgary AB T2H 1L9
403-255-7884

Halliburton Cementing
1600, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
403-231-9300 www.halliburton.com

Halliburton Completion Tools
1600, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
403-231-9300

Halliburton Group Canada
1600, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
403-231-9300 www.halliburton.com

Halliburton Production Enhancement
1600, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
403-231-9300 www.halliburton.com

Hertz Equipment Rental
8660 - 61 Ave. Edmonton AB T6E 5P6
780-435-3711 www.hertzequip.com

High Arctic Energy Services Inc.
8112 Edgar Industrial Dr. Red Deer AB T4P 3R2
403-340-9825 www.haes.ca

HiTech Fluid Systems Ltd.
1800, 505 - 3 St. S.W. Calgary AB T2P 3E6
403-547-2906 www.hitechfluid.com

Hi-Tech Seals Inc.
9211 - 41 Ave. N.W. Edmonton AB T6E 6R5
780-438-6055 www.hitechseals.com

Honeywell
5925 Centre St. S.W. Calgary AB T2H 0C2
403-509-1200 www.honeywell.com/acs/indsol

Horizontal Well Testing Ltd.
512, 7620 Elbow Dr. S.W. Calgary AB T2V 1K2
403-880-4030 www.horizontalwelltesting.com

Hot Rods Oilfield Services Inc.
Box 428 Carnduff SK S0C 0S0
306-928-2245 www.hotrodsoilfieldservices.com

Hotshot Fire Trucks Ltd.
51532 Range Rd. 25 Box 2728 Stony Plain AB T7Z 1Y2
780-823-0063 www.hotshotfiretrucks.com

Hotwell Canada Ltd.
516 Moraine Rd. N.E. Calgary AB T2A 2P2
403-247-3480 www.hotwell.ca

Husky Transport Ltd.
12155 - 242 Rd., Box 6070 Fort St. John BC V1J 4H6
250-785-8335 www.huskytransport.com

Hyduke Mechanical & Machining
2311 - 8 St. Nisku AB T9E 7Z3
780-955-9559 www.hyduke.com

ICS Group Inc.
250081 Mountain View Trail Calgary AB T3Z 3S3
403-247-4440 www.icsgroup.ca

Impact Rock Bits
Box 6448 Peace River AB T8S 1S3
780-624-2640 www.impactrockbits.com

Import Tool Corporation Ltd.
5533 - 48 St. N.W. Edmonton AB T6B 3R1
780-434-6406 www.importtool.com

Infinity Oilfield Services Inc.
219 A, 28042 Hwy. II R.R. 2
Red Deer County AB T4S 2L4
403-230-6031 www.infinityoilfield.com

Integrated Production Services Ltd.
1900, 840 - 7 Ave. S.W. Calgary AB T2P 3G2
403-266-0908 www.ipsadvantage.ca

International Frontier Resources Corporation
100, 601 - 10 Ave. S.W. Calgary AB T2R 0B2
403-215-2781 www.internationalfrontier.com

Isotopes Canada Ltd.
3, 1216 - 34 Ave. N.E. Calgary AB T2E 6L9
403-250-3968 www.isotopescanada.com

John Crane Canada Inc.
423 Green Rd. Stoney Creek ON L8E 3A1
905-662-6191 www.johncrane.com

Kanex Energy Corp.
41 Springland Way Calgary AB T3Z 3N6
403-240-1863

Kayden Industries Inc.
1640, 801 - 6 Ave. S.W. Calgary AB T2P 3W3
403-615-7709 www.kayden.ca

Keddco Mfg. Ltd.
645 Keddco St., Sarnia ON N7T 7K6
519-336-2960 www.keddco.com

Ketek Group Inc.
20204 - 110 Ave. N.W. Edmonton AB T5S 1X8
780-447-5050 www.ketek.ca

Klass Mechanical Sales Ltd.
10, 3610 - 29 St. N.E. Calgary AB T3A 0E8
403-286-7467 www.klassmechanical.ca

KSM Inc.
1904 - 4 St. Nisku AB T9E 7T8
780-955-3456 www.ksmrig.com

Kudu Industries Inc.
9112 - 40 St. S.E. Calgary AB T2C 2P3
403-279-5838 www.kudupump.com

Lanco Well Services (Elk Point) Corp.
14630 - 119 Ave. Edmonton AB T5L 2P2
780-452-3744

Lanco Well Services Ltd.
14630 - 119 Ave. N.W. Edmonton AB T5L 2P2
780-452-3744

Leader Energy Services Ltd.
700, 706 - 7 Ave. S.W. Calgary AB T2P 0Z1
403-265-5400 www.leaderenergy.com

Lochterra Inc.
Box 2096, Stn. M Calgary AB T2P 2M4
403-651-4090

Lockwell Servicing Ltd.
Box 700 Kindersley SK S0L 1S0
306-838-2014

Logan International Inc.
Suite 850, 635 8th Ave. S.W. Calgary, AB T2P 3M3
403-930-6810

M.W. Hagel Consulting Ltd.
18 Golden Key Estates Calgary AB T3P 1A5
403-265-7800 www.optimus.ab.ca

Marquis Alliance Energy Group Inc.
1800, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-264-1588 www.marquisalliance.com

Matrix Drilling Fluids Ltd.
1240, 540 - 5 Ave. S.W. Calgary AB T2P 0M2
403-265-7660 www.matrixdrillingfluids.com

Maxquip Inc.
6235A - 86 Ave. S.E. Calgary AB T2C 2S4
403-258-3685 www.maxquip.ca

Mayco Well Servicing Inc.
Box 575 Oxbow SK S0C 2B0
306-483-2367 www.maycowell.com

McAdoo Flow-Systems Ltd.
Bay 6, 6115 - 4 St. S.E. Calgary AB T2H 2H9
403-547-5002 www.mcadooflowsystems.com

M-I SWACO
200, 125 - 9 Ave. S.E. Calgary AB T2P 0G6
403-290-5300 www.miswaco.com

Miller Well Servicing Ltd.
Box 1341 Weyburn SK S4H 3J9
306-861-6154

Mow-Tech Ltd.
17740 - 118 Ave. N.W. Edmonton AB T5S 2W3
780-484-6356 www.mowtech.com

Mud Master Drilling Fluid Services Ltd.
530, 1015 - 4 St. S.W. Calgary AB T2R 1J4
403-237-8900 www.mudmaster.ca

Muis Controls Ltd.
29 Riel Dr. St. Albert AB T8N 3Z2
780-459-7080 www.muiscontrols.com

Nabors Production Services
33 Schenk Industrial Rd. Sylvan Lake AB T4S 2J7
403-887-7400 www.nabors.com

Nalco Champion
2200, 144 - 4 Ave. S.W. Calgary AB T2P 3N4
403-234-7881 www.champ-tech.com

National Process Equipment
5049 - 74 Ave. S.E. Calgary AB T2C 3H2
403-219-0270 www.natpro.com

Navigator Resource Consulting Ltd.
610, 7015 Macleod Trail S.W. Calgary AB T2H 2K6
403-233-7380 www.navigator-resource.com

NCS Oilfield Services Canada
800, 840 - 7 Ave. S.W. Calgary AB T2P 3G2
403-988-6342 www.ncsfrac.com

Nelgar Services Inc.
101, 7477 - 49 Ave. Red Deer AB T4P 1N1
403-309-2620 www.nelgarservices.com

Netzsch Canada, Inc.
740 Huronia Rd. Barrie ON L4N 6C6
705-797-8426 www.netzsch.ca

Newpark Canada Inc.
300, 635 - 6 Ave. S.W. Calgary AB T2P 0T5
403-266-7383 www.newpark.ca

Northern Pressure Systems Inc.
1000, 825 - 8 Ave. S.W. Calgary AB T2P 2T3
403-262-4698

Northstar Drillstem Testers Inc.
201, 736 - 1 Ave. N.E. Calgary AB T2E 0B8
403-265-8987 www.northstardst.com

NOV Coil Tubing and Pressure Pumping Canada
4800 - 27 St. S.E. Calgary AB T2B 3M4
403-279-9696 www.nov.com

NOV Wilson Canada
1800, 635 - 8 Ave. S.W. Calgary AB T2P 3M3
403-531-5600 www.nov.com

Oak Environmental Inc.
103, 4712 - 13 St. N.E. Calgary AB T2E 6P1
403-250-9810 www.oakenviro.com

Oil & Gas Instruments Inc.
3, 265 Main St., Box 237 Glencoe ON N0L 1M0
519-287-3554

Oil Lift Technology Inc.
37 - 19 Ave. N.E. Calgary AB T2E 8Z9
403-291-5300 www.oilliftechnology.com

OilPro Oilfield Production Equipment Ltd.
530 Cleveland Cr. S.E. Calgary AB T2G 4A9
403-215-3373 www.oilpro.ab.ca

Opsco Energy Industries Ltd.
285175 Kleysen Way Rocky View AB T1X 0K1
403-272-2206 www.opscoenergy.com

OptiFrac Chemicals Services
530, 1015 - 4 St. S.W. Calgary AB T2R 1J4
403-237-8900 www.optifrac.com

Optimus International Technologies Inc.
18 Golden Key Estates Calgary AB T3P 1A5
403-265-7800 www.optimus.ab.ca

Pacific Valve Services Inc.
9750 - 62 Ave. Edmonton AB T6E 0E3
780-463-3972 www.pacificvalve.com

Packers Plus Energy Services Inc.
2200, 205 - 5 Ave. S.W. Calgary AB T2P 2V7
403-263-7587 www.packersplus.com

Pajak Engineering Ltd.
300, 707 - 7 Ave. S.W. Calgary AB T2P 3H6
403-264-1197 www.pajakeng.com

Parcels Trucking (2007) Ltd.
4713 - 41 St. Stettler AB T0C 2L0
403-742-2781

ParVal Equipment Ltd.
201, 14207 - 128A Ave. Edmonton AB T5L 4P5
780-437-2334 www.parval.ca

PCM Canada
303, 6707 Elbow Dr. S.W. Calgary AB T2V 0E5
403-252-8902 www.pcm.eu

Peace Country Rentals & Sales Inc.
9619 - 108 St. Fort St. John BC V1J 6S4
250-785-8951 www.peacecountryrentals.com

Pembina Controls Inc.
9611 - 42 Ave. Edmonton AB T6E 5R2
780-432-6821 www.pem-controls.com

Penetrators Canada Inc.
8002 Edgar Industrial Ave. Red Deer AB T4P 3S2
403-346-7474 www.maxperf.ca

Penta Completions Supply & Services Ltd.
9543 - 56 Ave. Edmonton AB T6E 0B2
780-436-6644 www.pentarods.com

Peterson Instruments
123, 5655 - 10 St. N.E. Calgary AB T2E 8W7
403-291-9169 www.petersoninst.com

Petro Management Group Ltd.
401, 100 - 4 Ave. S.W. Calgary AB T2P 3N2
403-216-5100 www.petromgt.com

Petroleum Technology Transfer Inc.
5008 Nesbitt Rd. N.W. Calgary AB T2K 2N5
403-282-6183

Photon Control Inc.
200, 8363 Lougheed Hwy. Burnaby BC V5A 1X3
604-422-8861 www.photon-control.com

Pimee Well Servicing Ltd.
Box 39 Kehewin AB T0A 1C0
780-826-6392

Platinum Pumpjack Services Corp.
Box 10207 Lloydminster AB T9V 3A3
780-875-7145 www.platinumenergy.net

Polycore Tubular Linings Corporation
430, 736 - 8 Ave. S.W. Calgary AB T2P 1H4
403-444-5554 www.polycore.ca

Porteous Resources Limited
5008 Nesbitt Rd. N.W. Calgary AB T2K 2N5
403-282-6183

Powerstroke Well Control Ltd.
R.R. 2, Site 33, Comp. 4 Grande Prairie AB T8V 2Z9
780-539-0102 www.powerstroke.ca

Precision Drilling Corporation
800, 525 - 8 Ave. S.W. Calgary AB T2P 1G1
403-716-4500 www.precisiondrilling.com

Presidential Industries Ltd.
2012 Box 279 Crossfield AB T0M 0S0
403-946-4845 www.texfence@telusplanet.net

Primary Flow Signal Canada, Inc.
4003 - 97 St. Edmonton AB T6E 5Y5
780-440-0109 www.primaryflowsignal.com

Production Equipment Performance Reporting Inc.
700, 521 - 3 Ave. S.W. Calgary AB T2P 3T3
403-966-7377 www.peprinc.com

Proficient Oil Tools Ltd.
105, 616 - 71 Ave. S.E. Calgary AB T2H 2R1
403-255-4070 www.proficientoiltools.com

ProMinent Fluid Controls Ltd.
490 Southgate Dr. Guelph ON N1G 4P5
519-836-5692 www.prominent.ca

PRO-ROD
3201 - 84 Ave. Edmonton AB T6P 1K1
780-449-7101 www.prorod.com

ProTechnics
2100, 125 - 9 Ave. S.E. Calgary AB T2G 0P6
403-269-2055 www.protechnics.com

Proven Reserves Exploitation Ltd.
1000, 888 - 3 St. S.W. Calgary AB T2P 5C5
403-218-7000 www.proven-reserves.com

Q'Max Solutions Inc.
1700, 407 - 2 St. S.W. Calgary AB T2P 2Y3
403-269-2242 www.qmaxsolutions.com

Raider Well Servicing Ltd.
6306 - 53 Ave. Lloydminster AB T9V 2E2
780-875-7373

Raise Production Inc.
2620 - 58 Ave. S.E. Calgary AB T2C 1G5
403-699-7675 www.raiseproduction.com

Rangeland Drilling Automation Inc.
Box 1350 Okotoks AB T1S 1B3
403-652-3253 www.rangelandinc.com

Rangeland Energy Services
Box 5098 High River AB T1V 1M3
403-652-3253 www.rangelandinc.com

Rebco Oil Tools Inc.
4226 Ogden Rd. S.E. Calgary AB T2G 4V3
403-243-1380 www.rebcooiltools.com

Redmont International ULC
3336 - 47 Ave. S.E. Calgary AB T2B 2W1
403-297-0910 www.redmont.com

Regent Energy Group Ltd.
3735 - 8 St. Nisku AB T9E 8J8
780-955-4288 www.regentenergygroup.com

Reliance Well Servicing (2002) Ltd.
Box 7285 Drayton Valley AB T7A 1S5
780-542-5295 www.reliancewell.com

Rheotech Drilling Fluid Services Inc.
610, 700 - 4 Ave. S.W. Calgary AB T2P 3J4
403-237-8870 www.rheotech.ca

Ringer Well Service Ltd.
Box 506 Cochrane AB T4C 1A7
403-208-9733 www.ringerwell.com

Robbins & Myers Energy Services Canada
3703 - 98 St. Edmonton AB T6E 5N2
780-465-9500 www.rmenergy.com

Rockwell Servicing Partnership
1000, 400 - 5 Ave. S.W. Calgary AB T2P 0L6
403-265-6361 www.ensignenergy.com

Rod Anderson Holdings Ltd.
399 Whiteridge Cres. N.E. Calgary AB T1Y 2Y9
403-293-0583

Roll'n Oilfield Industries, Ltd.
305, 5208 - 53 Ave. Red Deer AB T4N 5K2
403-343-1710 www.rolln.com

Ronwood Enterprises Ltd.
Box 600 Consort AB T0C 1B0
403-577-2060 www.ronwoodpressuretrucks.com

Ross Energy Services Ltd.
66 Cranridge Heights S.E. Calgary AB T3M 0C1
403-236-0122

Rotation Power & Equipment Inc.
Box 500 Neilburg SK S0M 2C0
306-823-4818 www.rotationpower.com

Royal Well Servicing Ltd.
5214 - 62 St. Lloydminster AB T9V 2E4
780-808-2333

S.A. Armstrong Limited
23 Bertrand Ave. Scarborough ON M1L 2P3
416-755-2291 www.armstrongpumps.com

Sabre Oilfield Equipment Ltd.
2412 Cameron Ravine Dr. Edmonton AB T6M 0J2
780-446-6054 www.sabreoilfield.com

Safety Boss Inc.
Bay 1, 2501 Alyth Rd. S.E. Calgary AB T2G 1P7
403-261-5075 www.safetyboss.com

Sanjel Corporation
622 - 5 Ave. S.W. Calgary AB T2P 0M6
403-776-4800 www.sanjel.com

Savanna Energy Services Corp.
800, 311 - 6 Ave. S.W. Calgary AB T2P 3H2
403-503-9990 www.savannaenergy.com

Savanna Well Servicing
800, 311 - 6 Ave. S.W. Calgary AB T2P 3H2
403-503-0650 www.savannaenergy.com

Saxon Energy Services Inc.
1700, 700 - 4 Ave. S.W. Calgary AB T2P 3J4
403-716-4150 www.saxonservices.com

Schlumberger
200, 125 - 9 Ave. S.W. Calgary AB T2G 0P6
403-509-4000 www.slb.com

Schneider Electric, Telemetry & Remote SCADA Solutions
48 Steacie Dr. Kanata ON K2K 2A9
613-591-1943 www.controlmicrosystems.com

Secure Energy Services Inc.
1900, 205 - 5 Ave. S.W. Calgary AB T2P 2V7
403-984-6100 www.secure-energy.ca

SEI Industries Ltd.
7400 Wilson Ave. Delta BC V4G 1H3
604-946-3131 www.sei-ind.com

Select Energy Systems Inc.
4215 - 54 Ave. S.E. Calgary AB T2C 2A2
403-243-7542 www.selectesi.com

Sentry Pumping Units International
1150, 444 - 5 Ave. S.W. Calgary AB T2P 2T8
403-775-7077 www.sentryinternational.net

Servipetrol Inc.
502, 903 - 19 Ave. S.W. Calgary AB T2T 0H8
403-266-2535 www.servipetrol.com

Servipetrol Resources Ltd.
502, 903 - 19 Ave. S.W. Calgary AB T2T 0H8
403-266-2535 www.servipetrol.com

Siberian Well Service Ltd.
Box 218 Brooks AB T1R 1B3
403-362-9155

SIGIT Automation
540, 734 - 7 Ave. S.W. Calgary AB T2P 3P8
403-723-4256 www.sigitautomation.com

Simark Controls Ltd.
10509 - 46 St. S.E. Calgary AB T2C 5C2
403-236-0580 www.simark.com

Sim-Con Oilfield Equipment Ltd.
800 - 10 St. West, Box 246 Kindersley SK S0L 1S0
306-463-4938 www.simconoil.com

Simmons Edeco Inc.
800, 906 - 12 Ave. S.W. Calgary AB T2R 1K7
403-244-5340 www.simmonsedeco.com

Slurry Cementers Ltd.
9525 - 62 Ave. Edmonton AB T6E 0E1
780-435-3451

Spartan Controls Ltd.
305 - 27 St. S.E. Calgary AB T2A 7V2
403-207-0700 www.spartancontrols.com

SPM Flow Control Ltd.
Unit A,8060 Edgar Industrial Red Deer AB T4P 3R3
403-341-3410 www.weiroilandgas.com

Stady Oil Tools Ltd.
300, 1601 Westmount Rd. N.W. Calgary AB T2N 3M2
403-262-8022

STEP Energy Services
300, 505 - 3 St. S.W. Calgary AB T2P 3E6
403-457-1772 www.stepenergyservices.com

Stewart & Stevenson, Canada
3111 Shepard Rd. S.E. Calgary AB T2C 4P1
403-215-5300 www.stewartandstevenson.com

Stowell Pumps
5415 - 99 St. Edmonton AB T6E 3N8
780-438-2485 www.stowellpumps.ca

Stream-Flo Industries Ltd.
4505 - 74 Ave. Edmonton AB T6B 2H5
780-468-6789 www.streamflo.com

Sure Flow Consulting Services (1992) Inc.
Box 7400 Bonnyville AB T9N 2H7
780-826-6864 www.sureflowservices.com

Syndicated Ventures Inc.
1500, 520 - 5 Ave. S.W. Calgary AB T2P 3R7
403-264-7474

Tank-Life Cradles Ltd.
Site 17, Box 24 Airdrie AB T4A 0P7
403-269-5525 www.tanklife.com

Tartan Controls Inc.
4003 - 53 Ave. Edmonton AB T6B 3R5
780-463-3366 www.tartancontrols.com

TDH Fluid Systems Inc.
112, 422 - 11 Ave. S.E. Calgary AB T2G 0Y4
403-228-7018

Techmation Electric & Controls Ltd.
117 Kingsview Rd. S.E. Airdrie AB T4A 0A8
403-243-0990 www.techmationelectric.com

Technicoil Corporation
1100, 250 - 2 St. S.W. Calgary AB T2P 0C1
403-509-0700 www.technicoilcorp.com

Tervita Corporation
500, 140 - 10 Ave. S.E. Calgary AB T2G 0R1
403-233-7565 www.tervita.com

TestAlta Services Ltd.
3011 - 23 St. N.E. Calgary AB T2E 7A4
403-250-1790 www.testalta.com

Tetrale Group Inc.
380, 1500 - 14 St. S.W. Calgary AB T3C 1C9
403-457-0555 www.tetrale.com

The Motor Company
5420 - 53 Ave. S.E. Calgary AB T2C 4R3
403-230-3055 www.themotorcompany.ca

The OPS Group International Inc.
4119 - 55 St. N.E. Calgary AB T1Y 4B5
403-216-1216

Thuro Inc.
4650 - 50 Ave. S.E. Calgary AB T2B 3R4
403-243-0276 www.thuro.ab.ca

Top-Co LP
7720 - 17 St. N.W. Edmonton AB T6P 1S7
780-440-4440 www.top-co.ca

Total Enerflex
9715 - 115 St. Grande Prairie AB T8V 5S4
780-532-8347 www.totalenerflex.com

Tracer Supervision
1110, 340 - 12 Ave. S.W. Calgary AB T2R 1L5
403-261-7097 www.barlon.ca

TRC Hydraulics Inc.
855 Champlain St. Dieppe NB E1A 1P6
506-853-1986 www.trchydraulics.com

Treeline Well Services Inc.
750, 333 - 11 Ave. S.W. Calgary AB T2R 1L9
403-266-2868 www.treelinewell.com

Trendon Bit Service Ltd.
Box 548 Redcliff AB T0J 2P0
403-548-7242 www.trendonbitservice.com

Tri 3" Well Servicing Ltd."
1, 5316 - 43 St., Box 743 Provost AB T0B 3S0
780-753-2927

Trican Well Service
2900, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
403-266-0202 www.trican.ca

Trinidad Drilling Ltd.
2500, 700 - 9 Ave. S.W. Calgary AB T2P 3V4
403-265-6525 www.trinidaddrilling.com

Tryton Tool Services
6702 - 56 St. Box 10667 Lloydminster AB T9V 3A7
780-875-0800 www.essentialenergy.ca

TS&M Supply
Box 28 Estevan SK S4A 2A2
306-634-6494 www.natoil.com

Tucker Energy Services Canada Inc.
900, 635 - 8 Ave. S.W. Calgary AB T2P 3M3
403-264-7040 www.tuckerenergy.com

Tuscany International Drilling Inc.
Unit 1950, 140 - 4 Ave. S.W. Calgary AB T2P 3N3
403-265-8258 www.tuscanydrilling.com

Twylight Pressure Controls Ltd.
10124 - 94 Ave. Fort St. John BC V1J 5J6
250-785-2178

Unified Valve Ltd.
4, 12181 - 44 St. S.E. Calgary AB T2Z 4H3
403-215-7800 www.unifiedvalve.com

Univar Canada Ltd.
9800 Van Horne Way Richmond BC V6X 1W5
604-273-1441 www.univarcanada.com

Variperm (Canada) Limited
7, 3424 - 26 St. N.E. Calgary AB T1Y 4T7
403-250-7263 www.variperm.com

Viking Pump of Canada, Inc.
661 Grove Ave., Box 398 Windsor ON N9A 6M3
519-256-5438 www.vikingpumpcanada.com

Viking Surplus Oilfield Equipment Ltd.
36 Hwy. 39 East, Box 1460 Estevan SK S4A 2L7
866-634-6612 www.vikingsurplus.com

Volant Products Inc.
4110 - 56 Ave. N.W. Edmonton AB T6B 3R8
780-490-5185 www.volantproducts.ca

Waste 'n WaterTech
321, 11979 - 40 St. S.E. Calgary AB T2Z 4M3
403-252-9056 www.watertech.ca

Waterflood Service and Sales Ltd.
Box 1490 Estevan SK S4A 2L7
306-634-7212 www.waterflood.com

Welltec Canada Inc.
4860 - 25 St. S.E. Calgary AB T2B 3M2
403-263-2248 www.welltec.com

West Rock Energy Consultants Ltd.
700, 138 - 4 Ave. S.E. Calgary AB T2G 4Z6
403-663-4860 www.westrock-energy.com

Western Energy Services Corp.
1700, 215 - 9 Ave. S.W. Calgary AB T2P 1K3
403-984-5916 www.wesc.ca

Wildcat Well Servicing Inc.
Box 2374 Kindersley SK S0L 1S0
306-463-1114

William Nichols Consulting
4616 Brockington Rd. N.W. Calgary AB T2L 1R6
403-701-9922 www.williamnichols.com

Wizard Well Servicing Ltd.
5211 - 65 St. Lloydminster AB T9V 2E8
780-875-6035

World Oil Tools Inc.
6, 3504 - 72 Ave. S.E. Calgary AB T2C 1J9
403-720-5155 www.worldoiltools.com

Wrangler Well Servicing Ltd.
6108 - 24 St. Lloydminster AB T9V 3J8
306-821-7292

XL Fluid Systems
1800, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-264-1588 www.xlfluids.com

XYLEM Water Solutions
300 av. Labrosse Pointe-Claire QC H9R 4V5
514-695-0100 www.xylemwatersolutions.com/ca

Zazula Process Equipment Ltd.
4609 Manitoba Rd. S.E. Calgary AB T2G 4B9
403-244-0751 www.zazula.com

Zedi Inc.
902 - 11 Ave. S.W. Calgary AB T2R 0E7
403-444-1100 www.zedi.ca

Ziff Energy Group
180, 6025 - 11 St. S.E. Calgary AB T2H 2Z2
403-234-4297 www.ziffenergy.com

ENVIRONMENT

A.F.M. Resources Ltd.
R.R. 2 Okotoks AB T1S 1A2
403-938-2158

Abandonrite
2800, 500 - 4 Ave. S.W. Calgary AB T2P 2V6
403-263-6777 www.nabors.com

ABKO Holdings (1977) Ltd.
2422, 246 Stewart Green S.W. Calgary AB T3H 3C8
403-262-3221

Accurata Inc.
120 MacEwan Park Rise N.W. Calgary AB T3K 4A1
403-295-1637 www.accurata.ca

Adoil Inc.
B11, 416 Meridian Rd. S.E. Calgary AB T2A 1X2
403-242-2201 www.adoil.net

Altus Geomatics Limited Partnership, Environmental & Forestry
17327 - 106A Ave. Edmonton AB T5S 1M7
780-481-3399 www.altusgeomatics.com

AMEC Environment & Infrastructure
140 Quarry Park Blvd. S.E. Calgary AB T2C 3G3
403-248-4331 www.amec.com

Aresco Ltd.
108 Varsity Cres. N.W. Calgary AB T3B 2Z4
403-247-1449

Ashbrooke Quality Assurance Ltd.
78038, 3295 Coast Meridian Rd.
Port Coquitlam BC V3B 7H5
604-552-0496 www.ashbrooke.com

Banner Consulting Services, Inc.
269 Valley Springs Terrace N.W. Calgary AB T3B 5P8
403-510-5351

Bearspaw Environmental Inc.
Box 7349 Drayton Valley AB T7A 1S5
780-898-1234

Bennett Jones LLP
4500, 855 - 2 St. S.W. Calgary AB T2P 4K7
403-298-3100 www.bennettjones.com

Black Gold Projects - Inspection
3809 South Island Hwy. Campbell River BC V9H 1M4
403-262-4653 www.black-gold.ca

Britt Land Services
1100, 630 - 6 Ave. S.W. Calgary AB T2P 0S8
403-266-5746 www.brittland.com

Calvin Consulting Group Ltd.
1A, 3850 - 19 St. N.E. Calgary AB T2E 6V2
403-547-7557 www.calvinconsulting.ca

Canadian Institute of Resources Law
3353 MFH, University of Calgary Calgary AB T2N 1N4
403-220-3200 www.cirl.ca

CanGas Solutions Inc.
2010, 444 - 5 Ave. S.W. Calgary AB T2P 2T8
403-452-7789 www.cangassolutions.com

Clear Environmental Solutions
720, 736 - 8 Ave. S.W. Calgary AB T2P 1H4
403-263-5953 www.clearenv.com

Cordy Oilfield Services Inc.
1000, 1520 - 4 St. S.W. Calgary AB T2R 1H5
403-266-2067 www.cordy.ca

Energy Insurance Group Ltd.
1500, 727 - 7 Ave. S.W. Calgary AB T2P 0Z5
403-261-6061 www.eigltd.com

EnviroConsult Inc.
1613, 246 Stewart Gr. S.W. Calgary AB T3H 3C8
403-804-4311 www.enviroconsultinc.com

Enviro-Guard Reclamation Inc.
252 Sienna Hills Dr. S.W. Calgary AB T3H 2Y8
403-540-9312

Envirosoft Corporation
10-B, 1235 - 64 Ave. S.W. Calgary AB T2H 2J7
403-225-8760 www.envirosoft.ca

Epic Environmental Technologies Inc.
48 Carlton St. Box 700 Redvers SK S0C 2H0
306-452-3200 www.epicenvirotech.com

FDI Acoustics Inc.
250, 600 Crowfoot Cres. N.W. Calgary AB T3B 0B4
403-547-9511 www.fdiacoustics.com

Frac Rite Environmental Ltd.
2, 4416 - 5 St. N.E. Calgary AB T2E 7C3
403-265-5533 www.fracrite.ca

Geo Webworks Inc.
2020, 801 - 6 Ave. S.W. Calgary AB T2P 3W2
403-301-4001 www.geowebworks.com

Geophysics GPR International Inc.
100, 2545 rue de Lorimier Longueuil QC J4K 3P7
450-679-2400 www.geophysicsgpr.com

Ghostpine Environmental Services Ltd.
111, 10699 - 46 St. S.E. Calgary AB T2C 5C2
403-291-9238 www.ghostpine.com

Golder Associates Ltd.
2535 - 3 Ave. S.E. Calgary AB T2A 7W5
403-299-5600 www.golder.com

HFP Acoustical Consultants Corp.
1140, 10201 Southport Rd. S.W. Calgary AB T2W 4X9
403-259-6600 www.hfpacoustical.com

Hunter and Associates/GIS
Unit 18, 2285 Dunwin Dr. Mississauga ON L5L 3S3
905-607-4120 www.hunter-gis.com

Hydrogeological Consultants Ltd.
17740 - 118 Ave. N.W. Edmonton AB T5S 2W3
780-483-7240 www.hcl.ca

HydroQual Laboratories Ltd.
4, 6125 - 12 St. S.E. Calgary AB T2H 2K1
403-253-7121

Integrity Land Inc.
9940 - 99 Ave. Fort Saskatchewan AB T8L 4G8
780-992-1500 www.integrityland.com

J.K. Engineering Ltd.
320, 7930 Bowness Rd. N.W. Calgary AB T3B 0H3
403-247-1777 www.jkeng.ca

Kanuka Thuringer LLP
1400, 2500 Victoria Ave. Regina SK S4P 3X2
306-525-7200 www.kanukathuringer.com

KCM Engineering Ltd.
84 Oakmount Way S.W. Calgary AB T2V 4Y1
403-807-6576

Keneco Environmental Services (2000) Inc.
200, 717 - 7 Ave. S.W. Calgary AB T2P 3H6
403-237-8137 www.kenecoenviro.com

LandSolutions LP
200, 601 - 10 Ave. S.W. Calgary AB T2R 0B2
403-290-0008 www.landsolutions.ca

LEHDER Environmental Services
210, 704 Mara St. Point Edward ON N7V 1X4
519-336-4101 www.lehder.com

Lorrnel Consultants
1915 - 11 St. S.E. Calgary AB T2G 3G5
403-233-0900 www.lorrnel.com

Marquis Alliance Energy Group Inc.
1800, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-264-1588 www.marquisalliance.com

McNally Land Services Ltd.
215, 5718 - 1A St. S.W. Calgary AB T2H 0E8
403-503-5263 www.mcnallyland.com

MediaLogic Inc.
105, 620 - 8 Ave. S.W. Calgary AB T2P 3G2
403-261-5690 www.naturalresource.ca

Milepost Manufacturing
43, 26004 Twp. Rd. 544 Sturgeon County AB T8N 0B6
780-459-1030 www.milepostmfg.com

Millennium EMS Solutions Ltd.
6111 - 91 St. Edmonton AB T6E 6V6
780-496-9048 www.mems.ca

Morgan Construction & Environmental Ltd.
17303 - 102 Ave. Edmonton AB T5S 1J8
780-733-9100 www.mcel.ca

Mustus Energy Ltd.
600, 340 - 12 Ave. S.W. Calgary AB T2R 1L5
403-800-4744 www.mustusenergy.ca

Naft Canada Resources Ltd.
125, 315 - 24 Ave. S.W. Calgary AB T2S 3E7
403-239-3003

New Paradigm Engineering Ltd.
10444 - 20 Ave. N.W. Edmonton AB T6J 5A2
780-448-9195 www.newparadigm.ab.ca

Nichols Environmental (Canada) Ltd.
17331 - 107 Ave. N.W. Edmonton AB T5S 1E5
780-484-3377 www.nicholsenvironmental.com

Nickpoint Environmental Services Inc.
110, 239 - 10 Ave. S.E. Calgary AB T2G 0V9
403-260-6702 www.nickpoint.ca

Nor-Alta Environmental Services Ltd.
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780-486-4931 www.nor-alta.com

North/South Consultants Inc.
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Outcrop Communications Ltd.
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867-766-6700 www.outcrop.com

Pratum Resource Consulting Ltd.
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403-717-0493 www.pratum.com

Production Equipment Performance Reporting Inc.
700, 521 - 3 Ave. S.W. Calgary AB T2P 3T3
403-966-7377 www.peprinc.com

Remedx Remediation Services Inc.
305, 1550 - 5 St. S.W. Calgary AB T2R 1K3
403-209-0004 www.remedx.net

Roy Northern Environmental Ltd.
Box 847 Fairview AB T0H 1L0
780-835-2682 www.roynorthern.com

Scace Environmental Advisors Inc.
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403-242-7103

Seaway Energy Services Inc.
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403-235-4486 www.seawayenergy.com

Seguin Construction (1979) Ltd.
913 - 8 St. N.W., Bag 10 Slave Lake AB T0G 2A0
780-849-3091 www.seguinconstruction.ca

Skypics
10420 Maplemont Rd. S.E. Calgary AB T2J 1W4
403-271-5094 www.skypics.ca

SLR Consulting
200, 1620 West 8 Ave. Vancouver BC V6J 1V4
604-738-2500 www.slrconsulting.com

Stantec Consulting Ltd.
10160 - 112 St. Edmonton AB T5K 2L6
780-917-7000 www.stantec.com

Tansley Associates Environmental Sciences
Bay 3, 1470 - 28 St. N.E. Calgary AB T2A 7W6
403-569-8566 www.tansleyaes.com

TERA Environmental Consultants
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403-265-2885 www.teraenv.com

Tervita Corporation
500, 140 - 10 Ave. S.E. Calgary AB T2G 0R1
403-233-7565 www.tervita.com

Trek Construction & Environmental Services Ltd.
63A Skyline Cres. N.E. Calgary AB T2K 5X7
403-274-1000 www.gettrekin.com

Vertex Resource Group Ltd.
121, 2055 Premier Way Sherwood Park AB T8H 0G2
780-464-3295 www.vertex.ca

Visser Consulting Ltd.
290, 6815 - 8 St. N.E. Calgary AB T2E 7H7
403-239-3797 www.visserconsulting.ca

Whitland Consulting Inc.
2320 McIntyre St. Regina SK S4P 2S2
306-757-8511

Williams Engineering Canada Inc.
200, 10065 Jasper Ave. Edmonton AB T5J 3B1
780-409-5300 www.williamsengineering.com

Wotherspoon Environmental Inc.
104, 429 - 14 St. N.W. Calgary AB T2N 2A3
403-269-4351 www.wenv.com

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Barnett Engineering Ltd.
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403-255-9544 www.barnett-engg.com

Benchmark Data Solutions
5, 4001 - 19 St. N.E. Calgary AB T2E 6X8
403-590-9101 www.benchmarkdata.ca

BH Electronics Ltd.
179 Inverness Way S.E. Calgary AB T2Z 2X6
403-278-2084 www.www3.telus.net/hendersb

Canadian Centre for Energy Information
1600, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-263-7722 www.centreforenergy.com

Carbon Controls Ltd.
Bay 124, 11979 - 40 St. S.E. Calgary AB T2Z 4M3
403-238-9944 www.carboncontrolsltd.com

Cartel Energy Services Inc.
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403-947-3334 www.cartelenergy.com

Energy Processing/Canada
500, 900 - 6 Ave. S.W. Calgary AB T2P 3K2
403-263-6881 www.northernstar.ab.ca

Firemaster Oilfield Services Inc.
4728 - 78A St. Close Red Deer AB T4P 2J2
403-342-7500 www.firemaster.ca

Focal Technologies Corp.
77 Frazee Ave. Dartmouth NS B3B 1Z4
902-468-2263 www.moog.com/marine

Glentel Wireless Solutions
8501 Commerce Crt. Burnaby BC V5A 4N3
604-415-6500 www.glentel.com

GrahamChandler Writers Inc.
311, 317 - 19 Ave. S.W. Calgary AB T2S 0E1
403-229-3309 www.grahamchandler.ca

Guardian Telecom Inc.
7552 - 10 St. N.E. Calgary AB T2E 8W1
403-258-3100 www.guardiantelecom.com

Infosat Communications, Inc.
3130 - 114 Ave. S.E. Calgary AB T2Z 3V6
403-543-8188 www.infosat.com

JuneWarren-Nickle's Energy Group
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403-209-3500 www.junewarren-nickles.com

Microhard Systems Inc.
150 Country Hills Landing N.W. Calgary AB T3K 5P3
403-248-0028 www.microhardcorp.com

Network Innovations Inc.
4424 Manilla Rd. S.E. Calgary AB T2G 4B7
403-287-5000 www.networkinv.com

Northern Transportation Company Limited
1209, 1014 - 103 Ave. Edmonton AB T5J 0H8
780-441-3932 www.ntcl.com

Platinum Communications Corporation
280, 550 - 71 St. S.E. Calgary AB T2H 0S6
403-301-4590 www.platinum.ca

Priority Leasing Inc.
3615 - 9 St. S.E. Calgary AB T2G 3C7
403-216-1930 www.priorityleasing.net

Propane Canada
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403-263-6881 www.northernstar.ab.ca

Rigstar Communications Inc.
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403-232-6900 www.stradenergy.com

TAC Solutions
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403-253-9642 www.tacsolutions.ca

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Dartmouth NS B3B 1T5
902-425-4774 www.otans.com

The Roughneck Buy & Sell
500, 900 - 6 Ave. S.W. Calgary AB T2P 3K2
403-263-6881 www.northernstar.ab.ca

Traverse LandGroup Ltd.
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403-265-1050 www.traverselandgroup.com

Trinity Electronics Systems Ltd.
10708 - 181 St. Edmonton AB T5S 1K8
780-489-3199 www.trinity-electronics.com

Western Midland Communications Ltd.
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403-250-9433

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905-643-8289 www.asifluid.com

Amorex Solutions Ltd.
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403-770-7865 www.amorex.com

AVEVA
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B & G Systems Canada
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416-646-2885 www.b-gsystemscanada.com

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403-614-3913 www.brillium.ca

Canadian Discovery Ltd.
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403-269-3644 www.canadiandiscovery.com

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403-250-1119 www.cgg.com

CGI Information Systems and Management Consultants Inc.
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403-218-8300 www.cgi.com

CL Consultants Limited
3601A - 21 St. N.E. Calgary AB T2E 6T5
403-250-3982 www.clconsultants.ca

Computer Modelling Group Ltd.
200, 1824 Crowchild Trail N.W. Calgary AB T2M 3Y7
403-531-1300 www.cmgl.ca

Copyseis Ltd.
6705 Fairmount Dr. S.E. Calgary AB T2H 0X6
403-253-3425 www.copyseis.com

CriticalControl Energy Services Inc.
1100, 840 - 7 Ave. S.W. Calgary AB T2P 3G2
403-705-7500 www.criticalcontrol.com/energyservices

CriticalControl Solutions Inc.
1100, 840 - 7 Ave. S.W. Calgary AB T2P 3G2
403-705-7500 www.criticalcontrol.com

Datacon Core Imaging Inc.
2410F - 2 Ave. S.E. Calgary AB T2E 6J9
403-270-9350 www.dataconimaging.com

Dynasoft Communications Inc.
Box 2403 Lloydminster SK S9V 1W5
780-808-8731 www.dynasoft2000.com

Energy Navigator
1200, 777 - 8 Ave. S.W. Calgary AB T2P 3R5
403-233-9400 www.energynavigator.com

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200, 7904 N. Sam Houston Parkway W.
Houston TX 77064
281-664-8200 www.energy-solutions.com

Enersight Corp.
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403-246-7447 www.enersight.com

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403-261-1820 www.entero.com

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403-213-4200 www.fekete.com

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9321 - 48 St. Edmonton AB T6B 2R4
780-462-2400 www.fluidlife.com

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900, 703 - 6 Ave. S.W. Calgary AB T2P 0T9
403-262-1992 www.geoLOGIC.com

Geomodeling Technology Corp.
1100, 665 - 8 St. S.W. Calgary AB T2P 3K7
403-262-9172 www.geomodeling.com

Glenbriar Technologies Inc.
1100, 736 - 8 Ave. S.W. Calgary AB T2P 1H4
403-233-7300 www.glenbriar.com

GuildOne, Inc.
940, 333 - 5 Ave. S.W. Calgary AB T2P 3B6
403-355-8900 www.guild1.com

Halliburton Group Canada
1600, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
403-231-9300 www.halliburton.com

Halliburton Landmark Software & Services
1600, 645 - 7 Ave. S.W. Calgary AB T2P 4G8
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810, 744 - 4 Ave. S.W. Calgary AB T2P 3T4
403-234-0342 www.ifp-canada.com

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200, 1331 Macleod Trail S.E. Calgary AB T2G 0K3
403-770-4646 www.ihs.com/energy

Independent Data Services (Canada) Inc.
1700, 840 - 7 Ave. S.W. Calgary AB T2P 3G2
403-209-1528 www.idsdatanet.com

Intergraph
1120 - 68 Ave. N.E. Calgary AB T2E 8S5
403-569-5500 www.intergraph.com/global/ca

Jason
610, 600 - 6 Ave. S.W. Calgary AB T2P 0S5
403-263-3340 www.jason.cgg.com

Jedex Equipment Ltd.
4, 4063 - 74 Ave. S.E. Calgary AB T2C 2H9
403-531-8670 www.jedex.ca

M.W. Hagel Consulting Ltd.
18 Golden Key Estates Calgary AB T3P 1A5
403-265-7800 www.optimus.ab.ca

Micotan Software Company Ltd.
210, 1011 - 1 St. S.W. Calgary AB T2R 1J2
403-910-1010 www.micotan.com

Neostream Technologies Inc.
600, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-245-6625 www.neostreamtech.com

Open Door Technology Inc.
108, 7710 - 5 St. S.E. Calgary AB T2H 2L9
403-777-2410 www.opendoor.ca

P2 Energy Solutions
2100, 639 - 5 Ave. S.W. Calgary AB T2P 0M9
403-774-1000 www.p2energysolutions.com

Pandell Technology Corp.
210, 4834 Richard Rd. S.W. Calgary AB T3E 6L1
403-271-0701 www.pandell.com

Paradigm Geoservices Canada Ltd.
2110, 125 - 9 Ave. S.E. Calgary AB T2G 0P6
403-571-1555 www.pdgm.com

Peloton Computer Enterprises Ltd.
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Petris Canada
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Petro Management Group Ltd.
401, 100 - 4 Ave. S.W. Calgary AB T2P 3N2
403-216-5100 www.petromgt.com

Production Equipment Performance Reporting Inc.
700, 521 - 3 Ave. S.W. Calgary AB T2P 3T3
403-966-7377 www.peprinc.com

Quest Computer Consultants
145, 6815 - 8 St. N.E. Calgary AB T2E 7H7
403-275-2775 www.geometrix.ca

RiskAdvisory, a division of SAS (Canada)
970, 401 - 9 Ave. S.W. Calgary AB T2P 3C5
403-263-7475 www.riskadvisory.com

Schlumberger Information Solutions (SIS)
200, 125 - 9 Ave. S.E. Calgary AB T2G 0P6
403-294-4300 www.slb.com/sis

Schneider Electric, Telemetry & Remote SCADA Solutions
48 Steacie Dr. Kanata ON K2K 2A9
613-591-1943 www.controlmicrosystems.com

SeisWare International Inc.
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SPT Group, A Schlumberger Company
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403-517-0111 www.xitechnologies.com

Zedi Inc.
902 - 11 Ave. S.W. Calgary AB T2R 0E7
403-444-1100 www.zedi.ca

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403-220-5346 www.chem.ucalgary.ca/asr

Audryx Petroleum Consulting Ltd.
2300, 635 - 8 Ave. S.W. Calgary AB T2P 3M3
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Canadian Enerdata Ltd.
201, 86 Ringwood Dr. Stouffville ON L4A 1C3
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DMK Drilling Fluids Ltd.
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403-233-9337 www.sulpetro.com

McLean & Partners Wealth Management Ltd.
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2100, 350 - 7 Ave. S.W. Calgary AB T2P 3N9
403-267-1100 www.capp.ca

Canadian Association of Petroleum Production Accounting
300, 840 - 6 Ave. S.W. Calgary AB T2P 3E5
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403-453-0178 www.choa.ab.ca

Canadian Institute of Resources Law
3353 MFH, University of Calgary Calgary AB T2N 1N4
403-220-3200 www.cirl.ca

Canadian Propane Association
616, 130 Albert St. Ottawa ON K1P 5G4
613-683-2270 www.propane.ca

Canadian Society for Unconventional Resources
420, 237 - 8 Ave. S.E. Calgary AB T2G 5C3
403-233-9298 www.csur.com

Canadian Society of Exploration Geophysicists
570, 400 - 5 Ave. S.W. Calgary AB T2P 0L6
403-262-0015 www.cseg.ca

Canadian Well Logging Society
2200, 700 - 2 St. S.W. Calgary AB T2P 2W1
403-269-9366 www.cwls.org

Desk and Derrick Club of Edmonton
51517 Range Rd. 221 Sherwood Park AB T8E 1H1
780-922-4936 www.deskandderrickedmonton.org

Desk and Derrick Club of Grande Prairie
9009 - 128 Ave. Grande Prairie AB T8X 8C7
780-832-7095 www.http://deskandderrick.ca

Industrial Gas Users Association Inc.
502, 350 Starks St. Ottawa ON K1R 7S8
613-236-8021 www.igua.ca

Leduc/Devon Oilfield Historical Society
50339 Hwy. 60 South Calmar AB T0C 0V0
780-987-4323 www.leducnumber1.com

Lloydminster Oilfield Technical Society
Box 2084 Lloydminster SK S9V 1R5
780-875-6664 www.lhos.ca

Merit Contractors Association
103, 13025 St. Albert Tr. Edmonton AB T5L 5G4
780-455-5999 www.meritalberta.com

National Research Council - Institute for Ocean Technology
Box 12093 St. John's NL A1B 3T5
709-772-2479 www.http://iot-ito.nrc-cnrc.gc.ca

Petroleum Joint Venture Association Box
6173, Stn. D Calgary AB T2P 2C8
403-244-4487 www.pjva.ca

Petroleum Services Association of Canada
1150, 800 - 6 Ave. S.W. Calgary AB T2P 3G3
403-264-4195 www.psac.ca

Petroleum Technology Alliance Canada
400, 500 - 5 Ave. S.W. Calgary AB T2P 3L5
403-218-7700 www.ptac.org

Resource Industry Suppliers Association
104, 14020 - 128 Ave. N.W. Edmonton AB T5L 4M8
780-489-5900 www.risa.com

The Association of Professional Engineers, and Geoscientists of Alberta
1500, 10060 Jasper Ave. N.W. Edmonton AB T5J 4A2
780-426-3990 www.apega.ca

The Association of Science and Engineering Technology Professionals of Alberta (ASET)
1630, 10020 - 101 A Ave. Edmonton AB T5J 3G2
780-425-0626 www.aset.ab.ca

The Explorers and Producers Association of Canada
1060, 717 - 7 Ave. S.W. Calgary AB T2P 0Z3
403-269-3454 www.explorersandproducers.ca

The Maritimes Energy Association
305, 202 Brownlow Ave. Cambridge 1
Dartmouth NS B3B 1T5
902-425-4774 www.otans.com

World Petroleum Council, Canadian Association
25076A, 801 - 7 Ave. S.W. Calgary AB T2P 3P7
403-218-2000 www.wpccanada.com

GOVERNMENT

Alberta Government - Department of Energy
9945 - 108 St. Edmonton AB T5K 2G6
780-427-8050 www.energy.alberta.ab.ca

BC Oil and Gas Commission
100, 10003 - 110 Ave. Fort St. John BC V1J 6M7
250-794-5200 www.bcogc.ca

British Columbia Government - Ministry of Energy, Mines and Natural Gas
Box 9326 Victoria BC V8W 9N2
250-952-0293 www.em.gov.bc.ca

Canada-Nova Scotia Offshore Petroleum Board
18 Fl., 1791 Barrington St. Halifax NS B3J 3K9
902-422-5588 www.cnsopb.ns.ca

Alberta Energy Regulator
1000, 250 - 5 St. S.W. Calgary AB T2P 0R4
403-297-8311 www.aer.ca

Manitoba Government - Department of Innovation, Energy and Mines
360, 1395 Ellice Ave. Winnipeg MB R3G 3P2
204-945-6577 www.gov.mb.ca

National Energy Board
444 - 7 Ave. S.W. Calgary AB T2P 0X8
403-292-4800 www.neb-one.gc.ca

New Brunswick Government - Department Energy
M 100, 1 Germain St. Saint John NB E2L 4V1
506-658-3180 www.gnb.ca

Newfoundland and Labrador Government - Department of Natural Resources
50 Elizabeth Ave. St. John's NL A1B 4J6
709-729-3017 www.nr.gov.nl.ca/nr/

Ontario Government - Ministry of Natural Resources
659 Exeter Rd. London ON N6E 1L3
519-873-4634
www.mnr.gov.on.ca/en/Business/OGSR/index.html

Saskatchewan Government Ministry of the Economy (ECON)
7 Fl., 2101 Scarth St. Regina SK S4P 2H9
306-787-2592 www.economy.gov.sk.ca

Yukon Government - Department of Energy, Mines and Resources - Oil & Gas Resources
300 - 211 Main St. Whitehorse YT Y1A 2B2
867-667-5087 www.yukonoilandgas.com

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