Innovation surge sparks oil sands opportunities

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Innovation surge sparks oil sands opportunities

Owing to Alberta’s 174 billion barrels of oil sands bitumen reserves, Canada has moved up the world ranking to third place in terms of crude oil reserves, behind Saudi Arabia and Venezuela. We believe that technology—made in Canada or otherwise—can make further dramatic increases in reserves and recovery rates. James Cleland, General Manager of Heavy Oil Solutions at GE says he sees the day coming “when the oil sands will be the world’s largest reserve of oil.” And as producers develop both incremental and breakthrough innovations, operations will continue to become safer, more efficient and more sustainable.

In creating this report, it was important for us to get the perspectives of industry leaders in a broad range of organizations. We interviewed oil sands executives from major oil and gas companies like Canadian Natural Resources Limited, Suncor Energy, Shell Canada, Imperial Oil, Brion Energy, Cenovus; independent in situ operators like Connacher Oil and Gas, Petrobank Energy & Resources Ltd., Athabasca Oil Corporation; and associations and suppliers like Canada’s Oil Sands Innovation Alliance (COSIA) and GE. We feel that their examples demonstrate how technologies and practices are transforming the industry. The companies we interviewed represent a sample of the many companies within Canada’s oil sands industry that continue to search for technological breakthroughs.

In our report we look at four “innovation surges” that are opening up a new era of opportunity for the oil sands industry:

1. Innovation reduces economic costs
2. Innovation improves environmental performance
3. Innovation accelerates through industry collaboration
4. Innovation converts more resources to reserves

Throughout the report we position short profiles of several important technologies that exemplify these surges. Many of these technologies were developed through industry-wide collaboration. This approach is breaking down corporate barriers, supporting the exchange of ideas and accelerating cycle time to develop and commercialize new technologies.

Our report reflects how the industry has a focused commitment to improving operational processes and environmental performance through investments in research and development. A better awareness of the scope of these efforts could effect a positive perception change about the oil sands industry with regard to its economics, environmental record and social license.

The right investments, partnerships and operational efficiencies throughout the value chain will continue to increase the opportunities that the oil sands present. Canada’s oil sands offers the world a long-term and secure source of energy, and will be a critical source in supplying the world’s growing demand for petroleum products, particularly in the rapidly expanding economies of Asia. Our conversations repeatedly underscored industry confidence that the resource can be developed responsibly. Our report looks at the unconventional solutions that are making this possible.
Alberta bitumen resources

Produced
4 billion bbls

Established reserves
174 billion bbls

Probable reserves
315 billion bbls

Non-recoverable
1.2 trillion bbls

Source: Rigzone

The right investments, partnerships and operational efficiencies throughout the value chain will continue to increase the opportunities that the oil sands present.

It’s necessary to distinguish between cooperation and collaboration. Cooperation is working together towards individual ends. A company interested in cooperation may be at the table for its own interests. Collaboration is working together towards shared interests. That’s what COSIA is all about.

Dan Wicklum, Chief Executive Officer, Canada’s Oil Sands Innovation Alliance (COSIA)
Innovation surge sparks oil sands opportunities

So where do we start? Innovation. Innovation is crucial to developing our resources responsibly and in a sustainable way, while also developing operational efficiencies. Looking at long-term impact, we need to focus on ways to use less water, reduce energy consumption, lower greenhouse gas (GHG) emissions and enhance productivity but at a lower cost.

There are two ways to do this. Mike Krayacich, Vice President Oil Sands and In-Situ Technical and Reliability at Suncor believes, “near-term technology development is focused on continuous improvement, particularly in attaining greater value from the firm’s asset base. On the other hand, long-term work is focused on breakthrough technologies that could bring about radical improvements in operational performance and recovery.” James Cleland at GE talks about how “thinking outside of the box” is a business imperative: “oil sands companies that are innovation leaders are also leaders in augmenting shareholder value.”

The transition from draglines and bucket wheels to trucks and hydraulic shovels is referred to as the breakthrough technology in the oil sands mining sector. This shift first became possible with the availability of trucks offering load capacities four times that of previous vehicles. On the in situ side, it is SAGD. SAGD is a production method that enables bitumen recovery from formations deeper than 75 metres beneath the surface. Since 80% of the bitumen resource is beneath this depth, the value of SAGD cannot be overestimated.

The general public, by and large, views oil sands operations as large companies with large reserves and environmental concerns attached to their production. What is underestimated is the innovation, research advancements and the focus on improving the environmental impacts through technological enhancements. These continuous technological improvements reduce unit costs and environmental impact. Technology is therefore one of the cornerstones for every oil sands company in operation today.

Reynold Tetzlaff, National Energy Leader, PwC Canada
There are many technologies under development that promise to improve performance operationally and environmentally. On the in situ side, SAGD is undergoing constant refinement. Chris Bloomer, Chief Executive Officer at Connacher Oil and Gas describes the company’s SAGD+® process method in which steam is co-injected with solvent. The result is higher bitumen recovery at a lower cost. Imperial Oil’s Liquid Addition to Steam for Enhancing Recovery (LASER) a next generation SAGD process, also holds great promise in reducing the viscosity of the bitumen, allowing it to flow better to the wellbore.

Change is constant, but it’s coming at a faster rate. The pace of innovation is being driven by the increasingly open exchange of ideas amongst engineers and geologists in the industry. The greater exchange comes from new industry alliances, some intra-corporate, some as partnerships with suppliers and others with government bodies. There’s an expectation that new technological development will build on the strengths—and avoid the weaknesses—of precedent ones. Joy Romero, Vice President Technology Development at Canadian Natural Resources Limited, describes this phenomenon as “every time we at Canadian Natural build something, it’s an order of magnitude better than it was the last time. It’s the same way with our peers.”

In fact, to the majority of oil sands companies, environmental and economic goals are consistent. By improving operational performance, a company simultaneously reduces its emissions footprint. One example was repeatedly mentioned: how steam-to-oil-ratios (SORs) demonstrate the close correlation between emissions intensity and natural gas consumption at thermal operations. SOR is a measure of energy intensity, but since the energy source used to generate steam is, in fact, a hydrocarbon (i.e. natural gas), SOR is also a good proxy indicator for greenhouse gas emissions. For oil sands companies, safeguarding the environment through innovation is of paramount importance.

Harbir Chhina, Executive Vice President Oil Sands at Cenovus says “our approach to innovation is that any technology that is good for the environment is also good for Cenovus.” Improvements in energy efficiency have led to a 26% reduction in emissions intensity in the oil sands industry-wide between 1990 and 2010. Joy Romero at Canadian Natural believes that “parity with conventional oil” for many types of oil sands projects is on the horizon. She describes a step to closing this gap is the addition of an algal bio-refinery to their Primrose facility that could reduce GHG emissions by 30%.

Don Verdonck, Executive Senior Vice President at Brion Energy, describes the long-term effects of innovation by saying that it gradually makes a very unconventional business conventional.

**BREAKTHROUGH TECHNOLOGIES**

**Athabasca Oil Corporation: Thermal Assisted Gravity Drainage (TAGD)**

Use of electrical energy to stimulate the reservoir instead of steam in in situ extraction.

Thermal Assisted Gravity Drainage (TAGD) is a potential production technology for the in situ recovery of bitumen resources contained in the porous carbonate reservoirs of the Leduc and Grosmont formations.

TAGD uses an array of downhole electrical resistance heaters installed in horizontal wells to heat the reservoir via thermal conduction to about 120 degrees. TAGD operates at lower temperatures than SAGD, leading to increased energy efficiencies and lower operational costs.

At Athabasca Oil Corporation’s pilot project recovery rates are expected to reach 65%, similar to SAGD. About 70% of a SAGD operation’s capital costs go towards water handling, conditioning and treatment. As TAGD requires no water during the bitumen recovery process, there’s no need for costly steam generation and water treatment facilities, so that operations could be half as expensive as a comparable SAGD project.

“...This process cuts the use of water out completely and AOC’s process uses less than half the energy of other electrical heating processes. That is a game changer.”

*Bob Gerwing, General Manager Engineering, Athabasca Oil Corporation*
Innovation surge sparks oil sands opportunities

**BrEakthrough tEchnologies**

**Imperial Oil: Liquid Addition to Steam for Enhancing Recovery (LASER)**

Addition of solvents with steam to mobilize the bitumen in the reservoir in in situ projects. From the original lab that patented SAGD.

After more than a decade of research and field trials, Imperial Oil is deploying a new technology in more than 200 wells at Cold Lake called LASER (Liquid Addition to Steam for Enhancing Recovery) as a complementary process to its Cyclic Steam Stimulation (CSS) extraction method. With LASER, low concentrations of pipeline diluent are co-injected with steam. The diluent (i.e. natural gas condensate) helps further reduce the viscosity of the bitumen, aiding its ability to flow to the wellbore.

Diluents are actually more valuable than the produced resource, so it’s critical to have a deep understanding of the comparative recovery rates of the bitumen and diluent under different conditions.

After a soak phase, the condensed water, diluent and heated oil are produced back from the same well, resulting in a more efficient production process. By adding diluent, more resource can be recovered from mature wells for the same amount of steam injected in traditional CSS production. LASER has the potential to reduce GHG intensity by approximately 25%.

The company is exploring other non-thermal processes—some of them also involving solvents—which would allow bitumen recovery from more technically challenging reservoirs and would allow, from an environmental standpoint, oil production that has a lower GHG intensity (or footprint) than most conventional oil.

“At Imperial Oil, we continue to invest in technological advancements that improve environmental performance and operational efficiency.”

*Rick Gallant, Vice-President, Oil Sands Development and Research, Imperial Oil*
In Canada’s oil sands industry, innovation and improved recoveries go hand-in-hand. Innovation helps to reduce operating costs, reduces the environmental footprint and reduces the required energy to run facilities—a win on all accounts. As a result, technology enhancements strengthen the overall economic position of Canadian oil sands players in the global energy commodities marketplace.
electrical submersible pumps (ESPs) as a means to replace natural gas to bring oil to surface while significantly reducing the SOR. “We have introduced ESPs in our Foster Creek and Christina Lake projects and they now have a combined steam-to-oil ratio of approximately 2.1 in 2012. With a low SOR comes lower water usage, more efficient use of steam, a reduction of emissions per barrel of oil recovered and an overall reduction in operating costs.” Across the widely different SAGD projects in the oil sands, SORs are largely in the 2:1 to 5:1 range. As different technologies continue to be developed and existing ones combined in new ways, the ratios will keep lowering. But non-aqueous extraction methods with solvents and/or thermal conduction open up entirely new approaches and requires new efficiency metrics. Executives reiterate just how young the oil sands industry still is. Bob Gerwing at Athabasca Oil Corporation says that technical advancements are changing SAGD at a rapid rate so much so that it “will be virtually unrecognizable in 10 years.” Mike Krayacich at Suncor believes there may be a great deal of excitement and focus on opportunities to improve efficiencies on the in situ side, but that “the story on mining extraction technologies is not played out by a long shot.” At each point in the production process there are opportunities for improvements. “There are a myriad of ways to bring down costs and we never tire of exploring them,” says Krayacich.

**BREAKTHROUGH TECHNOLOGIES**

**Shell Canada: Carbon Capture and Storage (CCS)**

The Quest Carbon Capture and Storage Project will reduce CO₂ emissions from Shell Canada’s oil sands operations by more than one million tonnes a year by capturing CO₂ from its Scotford upgrader and permanently storing it deep underground.

The technology involved in each of the three components of CCS—capture, transport and storage—exists today.

The Quest CCS Project will capture up to 35% of the emissions from Shell Canada’s Scotford upgrader hydrogen manufacturing units. An absorber vessel captures the CO₂ with an amine solvent and this is then released from the amine by heating. The CO₂ will be dehydrated and compressed into a dense fluid for safe pipeline transport.

The captured CO₂ will be transported by pipeline to a well site where it will be injected more than two kilometres underground into the deepest saline formation in Alberta known as the Basal Cambrian Sands. The CO₂ will be trapped within tiny pore spaces between the grains of the sandstone rock formation and by dissolving into the brine of the saline formation.

This first-ever Albertan CCS project will establish initial infrastructure and support Alberta and Canada’s drive to address climate change. The experience gained locally through the early implementation of CCS demonstration projects such as Quest will prove invaluable in developing the capability and the capacity to enable industrial facilities to reduce greenhouse gas emissions.

The project has been funded and is under construction. Injection of CO₂ will begin in 2015.

[Shell Canada’s] Quest will be the first project in Alberta to receive the rights to inject CO₂ into “pore space” under provincial Carbon Capture and Storage (CCS) legislation enacted only just two years ago. It will capture more than one million tonnes of CO₂ per year from the Scotford Upgrader. That roughly equates to the emissions of 175,000 cars.

*David Onderwater, Manager Heavy Oil Technology Development, Shell Canada*
Many industry executives have endorsed collaborative initiatives to develop technologies that reduce impacts on water, land and air. There have been great improvements on the environmental impact of these projects but most companies would agree there is still a lot of room for improvement which is a driving force behind many of the new innovations that we see occurring today.

Innovation improves environmental performance

Canada is emerging as a world leader in environmental mitigation technologies for unconventional resource extraction practices. The pursuit of better environmental outcomes is a push and pull; a push from within the industry and a pull from regulatory institutions. Environmental performance capabilities keep improving while regulatory standards keep getting stricter. But it’s not always clear which is leading and which is following.

Alberta is currently investing CA$1.3 billion over 15 years in two large-scale carbon capture and storage (CCS) projects. One of these projects is Shell Canada’s Quest CCS project. This project will send over one million tonnes of carbon dioxide per year from Shell Canada’s Scotford upgrader near Edmonton to an injection location for permanent underground storage.

David Onderwater, Manager Heavy Oil Technology Development at Shell Canada says, “one of the appeals of CCS is that it demonstrates the technical feasibility of implementing really large-scale projects. We will be addressing the emissions of large carbon dioxide emitters while, at the same time, developing the framework and infrastructure to support broader deployment.”

Mike Krayacich draws attention to what Suncor is doing to convert fluid fine tailings more rapidly into a solid landscape suitable for reclamation. The use of the newly developed Tailings Reduction Operation (TRO™) reclamation method is expected to shorten the consolidated tailing approach of 30 years to 10 years and significantly reduce the company’s existing tailings inventory.
Since 1990, GHG emissions associated with every barrel of oil sands crude produced have been reduced by 26%.

Joy Romero at Canadian Natural talked about oil sands operators cutting their emissions profile to the point where they could achieve parity with a conventional producer. “Right now at Horizon we’re building on-site thickeners and transferring our tailings from a conventional to a non-segregating operation. The non-segregating tailings may cost CA$2.1 billion but since it lowers overall operating costs, it actually pays for itself. Consider this: once it’s been built you’ll have tailings you can walk on, water use is halved, emissions are down 16%. That puts the emissions intensity of this integrated facility below the best of what’s now out there. And there’s more: our algae bio-refinery project will bring emissions down another 15%. Right there, we’ve just dropped below conventional oil in terms of greenhouse gases—and that was supposed to be impossible to do.”

In 2012, Suncor withdrew 26.61 million cubic metres of water from the Athabasca River, while releasing 11.02 million cubic metres of treated water back into the river. Moreover, Suncor’s gross fresh water withdrawal from the Athabasca River

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### Life-cycle water use of various energy sources

- Oil sands mining
- Oil sands in situ
- Conventional oil
- Corn ethanol
- Soy biodiesel
- Coal-to-liquids
- Gas-to-liquids

Use per gigajoule of energy

Source: Cambridge Energy Research Association, US Department of Energy

### Life-cycle GHG emissions of various crude oils

- Common US conventional oil imports
- US domestic
- Oil sands

Source: Jacobs Consultancy, Life Cycle Assessment Comparison for North American and Imported Crudes, June 2009
has declined by 52% since 2004 when 56 million cubic metres of fresh water was withdrawn.

On the in situ side, the same positive story is playing out. Merle Johnson, Chief Operating Officer at Connacher Oil and Gas told us how its water treatment system with evaporators and drum boilers at Connacher’s Great Divide SAGD facility has raised water recycling rates above 95%. This water treatment system enables the exclusive use of non-potable water resulting in lower costs and considerable environmental benefits. Today, several companies are working on non-aqueous in situ extraction methods which would eliminate water almost entirely from in situ operations. Examples of such emerging technologies are underground combustion (i.e. Toe to Heel Air Injection or THAI®) and conductive heating (i.e. Thermal Assisted Gravity Drainage or TAGD).

Oil sands companies show that they’re responsible members of the communities where they operate through their commitment to restoring the integrity and health of disturbed ecologies. It’s a stewardship principle endorsed by all industry players and mandated by law.
The facility planned for CNRL’s Primrose site near Bonnyville would create products such as fuel, fertilizer and livestock feed. Pond’s technology feeds carbon dioxide emissions to algae. Waste heat and water from Canadian Natural’s operations will also be used to help the algae grow. As it blooms, the algae develop fatty oil which can be blended with heavy bitumen to make it flow more easily through pipelines, or sold to refiners, who can turn it into diesel or gasoline.

The material left behind once the oil has been stripped out can be used as a fertilizer, which CNRL could use in reclaiming oil sands mines. The algae biorefinery could drop CO₂ emissions 15% at CNRL’s Horizon mining operation, 30% at its Primrose operation.

The algae technology will be shared with Canada’s Oil Sands Innovation Alliance, the group of 13 oil sands companies that share environmentally friendly technologies without intellectual property concerns getting in the way.

The algae process involves the following steps:

1. **CO₂** enters the photobioreactor along with light, creating algae.
2. The algae and waste heat are harvested.
3. The algae are used to produce bio-oil, biodiesel, nutraceuticals, livestock feed and fertilizer. The remaining material is reclaimed for use as a fertilizer.
Innovation accelerates through industry collaboration

Collaboration has been an important driver of oil sands innovation for decades. The Alberta Oil Sands Technology and Research Authority (AOSTRA), was a government-funded initiative that supported the search for ways to make in situ resources economically recoverable. The Oil Sands Tailings Consortium (OSTC) and the Oil Sands Leadership Initiative (OSLI), both founded in 2010, were formed to share technical resources for environmental benefits. OSTC and OSLI were recently absorbed into Canada’s Oil Sands Innovation Alliance (COSIA), the next level of industry-wide oil sands collaboration.

COSIA’s 13 members, representing almost 90% of oil sands production, agree to share experience and intellectual property with other member companies. Under the old non-collaborative model, companies were protective of their intellectual property, regardless of whether it was surface or subsurface technology. The collaborative approach of COSIA, is based on the belief that industry should remain competitors but collaborate where the potential environmental benefits are great. Through the sharing of innovation and the application of these technologies, members minimize duplication of efforts and accelerate the pace of environmental performance improvement. Sharing is done in a manner that values and protects corporate technologies, but still provides access to the COSIA companies to apply and build on these technologies. To date, COSIA member companies have shared 560 distinct technologies and innovations that cost almost CA$1 billion to develop.

Oil sands companies differ widely in size, culture, type (i.e. mining and extraction, in situ, upgrading), experience, reservoir, technology, environmental performance, and products. An established 500,000 barrel per day integrated oil sands producer

The oil sands industry is unique in that it’s in the rare position whereby technological enhancements do not only improve the environmental and operational results of the company that develops the newest technology, it benefits the industry overall. We believe this is the reason behind the strong collaboration among many of the oil sands companies today. It’s this collaboration that has resulted in technological advancements occurring at a much quicker pace than conceived of even five years ago.
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“In the past there was a greater need to keep things secret, but this has become very difficult to do today,” says Don Verdonck at Brion Energy. “People will collaborate as long as the industry as a whole is moving forward.”

The will to collaborate on overcoming environmental challenges demonstrates just how seriously companies take their obligations to mitigating impacts on air, water and land.

Though competition remains fierce in the field of subsurface technologies, broad collaboration is happening in the development of environmental performance tools. Smaller oil sands companies, for example, lack the resources for extensive in-house R&D programs and see themselves better served by working with suppliers to customize available technology solutions to their project-specific challenges. Other companies have international operations that draw on the know-how of multinational teams composed of highly trained engineers. As Mike Krayacich at Suncor says, “we’ll parcel out pieces of research into bitumen extraction or chemical process or physical chemistry, but all the thinking is really here—this is where the integration happens.”

To date, COSIA member companies have shared 560 distinct technologies and innovations, that cost almost CA$1 billion to develop.

“In the past there was a greater need to keep things secret, but this has become very difficult to do today,” says Don Verdonck at Brion Energy. “People will collaborate as long as the industry as a whole is moving forward.”

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**BREAKTHROUGH TECHNOLOGIES**

**Suncor Energy: TRO™ Tailings Reclamation**

The accelerated drying process for mature fine tailings involving the addition of a polymer flocculent.

In the extraction process, oil sands mines produce a mixture of water, clay, sand and residual bitumen. When released into a tailings pond, the heaviest material settles to the bottom, water rises to the top, but fine clay particles suspended in water make up the middle layer. Since this middle layer or “mature fine tailings” (MFT) does not settle within a reasonable timeframe, oil sands mines have needed more and larger tailings ponds over the years.

Suncor developed a technique called the TRO process that significantly improves the speed of tailings reclamation and leads to the reduction of existing tailings inventory. In this process, MFT is mixed with a polymer flocculent, then deposited in thin layers over sand beaches with shallow slopes where it dries in a matter of weeks rather than years or even decades as before.

Subsequent to regulatory approval, the company expanded its TRO tailings management approach and, in the summer of 2010, processed approximately 2.9 million tonnes of tailings fines, a fifteen-fold increase from the previous year.

TRO technology has enabled the company to cancel plans for five additional tailings ponds at its existing mine operations. Furthermore, it now expects to reduce the number of tailings ponds at its present mine from the current eight to just two — shrinking the total land area covered by the ponds by approximately 80%. Suncor is sharing details specific to its TRO process with Canada’s Oil Sands Innovation Alliance (COSIA) whose members have pledged to remove barriers to collaboration on future tailings research and development.

A Suncor employee shows the results of TRO: dry material that is capable of being reclaimed in place or moved to another location for final reclamation.
Surge #4

Innovation converts more resources to reserves

There are many ways in which technology is converting resources to reserves. “The better we can characterize the formation, the more bitumen we can produce,” says Chris Bloomer at Connacher Oil and Gas.

Harbir Chhina at Cenovus referenced his company’s use of Wedge Well™ technology as a way of producing a higher percentage of the bitumen resource. “In SAGD operations, we drill horizontal wells in pairs, one well above the other. Wedge Well™ technology allows us to access that wedge of bitumen between two SAGD well pairs and pump the oil to the surface through drilling a single additional horizontal well. This technology assists in working towards increasing total recovery while lowering the environmental impact.”

Bob Gerwing considers Athabasca Oil Corporation’s Thermal Assisted Gravity Drainage (TAGD) as an example of a breakthrough technology. Since TAGD mobilizes the reservoir with electrical conduction instead of natural gas-heated steam, water use is eliminated and the steam-to-oil-ratio is infinitely reduced. TAGD will open up the development of vast formations previously inaccessible to conventional SAGD. Examples include the Grosmont and Winterburn carbonates where there are an estimated 471 billion barrels of untapped bitumen in place.

Don Verdonck at Brion Energy put today’s technological situation into historical perspective. He recalled how horizontal drilling was seen as a huge technological leap when it enabled production from previously inaccessible conventional fields. He regards Athabasca Oil Corporation’s development of TAGD as another game-changer because it expands reserves almost on par with Dr. Roger Butler’s application of horizontal drilling to deep-lying bitumen.

Alberta’s oil sands contain approximately 1.84 trillion barrels of bitumen-in-place, technology and economics determine what percentage of the resource is ultimately recoverable. As technology advances we see companies booking more of the contingent resource as proved-plus-probable reserves and increasing recovery rates.
Innovation surge sparks oil sands opportunities

formations, which led to SAGD. “With thermal conduction, you have something different than traditional SAGD technology. The emissions profile is also different. The water profile is zero. But like SAGD it opens up a whole new realm of opportunity.”

Robust international oil prices have been an important driver for strong investment in technologies that improve oil sands economics in relation to other varieties of crude. Growing worldwide crude oil demand, particularly amongst developing nations in Asia, are likely to continue to support strong crude oil prices and position the oil sands as a vital source of increasing global crude oil supply. Alberta has become a vital international centre of heavy oil research and innovation. Companies, government-funded organizations and academia are increasingly collaborating to come up with transformative technological developments. The successive deployment of new solutions and approaches are dramatically increasing recovery rates and reserves. As a result of the improvements in recovery and the outlook for further breakthrough improvements in the future, Canada’s oil sands continue to represent an attractive investment.

**BREAKTHROUGH TECHNOLOGIES**

Petrobank Energy & Resources Ltd.: Toe to Heel Air Injection (THAI®)

Conventional in-situ combustion technology has existed since the 1920’s, however, there are inefficiencies in its most common configuration of combining vertical air injection with vertical oil production wells. The THAI® configuration of combining one or more vertical air injection wells to a horizontal oil production well is designed to improve on existing combustion technology to increase oil recovery and economic returns. Combustion technology involves the injection of air into an oil reservoir, resulting in a chemical process which “burns” the heavier ends of the oil, and heats and lowers the viscosity of the remaining oil. The hot oil is more mobile than the native cold oil and, with gravity, moves to the horizontal production well to be produced to surface. The THAI® combustion process also upgrades the native oil in-situ by approximately 5° API.

Petrobank owns the THAI® patent, along with other patents for different combustion configurations and combustion related technologies. Petrobank has applied the THAI® combustion process in the field since 2006 in an oil sands reservoir and a heavy oil reservoir. Since its first field test, the equation has been simple: air in generates upgraded oil out. Many questions about the technology have been resolved, as the company has demonstrated the ability to sustain and control combustion, create high but manageable reservoir temperatures, produce upgraded sales oil and utilize simple and scalable surface facilities with standard oilfield equipment. Several environmental benefits have also been proven, including a small surface footprint, minimal natural gas use, and net water generation.

Petrobank continues to optimize THAI®, which is now being used at its Kerrobert heavy oil property in Saskatchewan, to prove the economic benefits of this process. Compared with SAGD, combustion requires only one horizontal well and does not require natural gas or large steam and water handling facilities, reducing both capital and operating costs. Petrobank has significant combustion experience in the field and believes that it can commercialize an improved combustion process for use in oil reservoirs in Canada and around the world.

The simple equation is: air in, upgraded heavy oil out.

*John D. Wright, Chairman, Petrobank Energy & Resources Ltd.*
Summary

Throughout our interviews, executives emphasized how a surge in innovation is speeding up the development and deployment of new technologies across all aspects of Canada’s oil sands business. The quick pace of innovation has however often left public awareness lagging behind the changing reality on the ground. Our report shows how step-out advancements in extraction and processing are rapidly replacing established oil sands technologies; they are also making many popular criticisms of the industry obsolete.

Canada’s oil sands look back on a rich history of research and development. Dr. Karl Clarke’s original development of the hot water process enabled the economic extraction of shallow-lying, mineable bitumen. Dr. Roger Butler’s development of SAGD did the same for deeper lying deposits. We are now witnessing the emergence of a host of breakthrough technologies of comparable significance that may make much of the oil sands industry virtually unrecognizable in 20 years’ time.

This report only touched on a few representative innovations. Bitumen extraction methods such as thermal conduction, solvent injection and in situ combustion hold the promise of unlocking currently unrecoverable oil sands deposits with minimal environmental impact. New water treatment facilities are eliminating the need for freshwater during in situ production and raising water recycle rates across the board to between 80% and 95%. New processes like Suncor’s TRO™ reclaim tailings ponds in a fraction of the customary time and will significantly reduce the existing ponds inventory. Efficiency improvements along the whole bitumen production and processing chain have brought down greenhouse gas emissions in oil sands operations by 26% between 1990 and 2011. Some executives point out that parity in environmental performance with some types of conventional oil production is now on the horizon.

“Capitalizing on our vast resources contained in the oil sands needs to be done responsibly so that 20 years from now we look back with pride knowing we left Alberta a better place and we did not waste this opportunity. A strong strategy around developing these resources responsibly through technological advancements is the first step toward achieving this goal.”

Reynold Tetzlaff, PwC Canada
We heard that the conversion of bold ideas into breakthrough solutions is not only capital-intensive, but very time-intensive. A new technology may require up to 20 years between the success of a pilot project and its eventual commercial deployment. Collaboration within industry and with government and academia is dramatically shortening development time by tearing down research silos, intensifying conceptual exchange and minimizing research duplication. Industry has cooperated with singular focus on initiatives such as Canada’s Oil Sands Innovation Alliance to promote the development of environmental mitigation technologies. The industry’s resolve to accelerate innovation and reduce cumulative environmental impact is highlighted by the way COSIA members share environmental technologies with competitors without fees or royalties.

The economic and environmental challenges facing the oil sands innovation community have been clearly delineated and progress is proceeding at a rapid pace. Collaboration, competition and regulatory forces mean that technology is always getting better, improving operational and environmental performance. The surge in innovation—both evolutionary improvements and revolutionary leaps—has brought forth a broad array of promising new technologies, many of which are on the verge of commercial maturity. This is a young industry whose resources have only relatively recently come under development. The momentum behind oil sands technology innovation points toward oil sands-derived crude bitumen providing a vital and sustainable energy source for Canada—and the world—for decades to come.

BREAKTHROUGH TECHNOLOGIES
Cenovus: Wedge Well™ Technology

Increasing oil recovery while lowering environment impact.

For its steam-assisted gravity drainage operations, Cenovus drills horizontal wells in stacked pairs, with multiple well pairs stemming out from a single well pad. Over time, a pocket or wedge of unrecovered bitumen forms in the space between contiguous SAGD well pairs. Wedge Well™ technology makes it possible to access that bitumen pocket by drilling a single horizontal production well between two such well pairs.

Wedge Well™ technology increases total recovery of oil while lowering the environmental impact. Since the pocket formation is surrounded by steam chambers created by the existing well pairs, it requires less water turned into steam to soften it and pump it to the surface. Lower steam requirements mean lower water and fuel consumption as well as a reduction in steam generator emissions intensity (emissions per barrel of oil produced).
SAGD operations involve the injection of high-quality steam into one horizontal well in order to liquefy bitumen for production through a second parallel one. Once at the surface, the produced water undergoes a complex three-step process where it is separated from the bitumen, treated to remove impurities, and recycled back to steam for re-injection.

The traditional warm lime softening (WLS) method had the drawback of not putting out water of a sufficient quality to take advantage of standard drum boilers which are less costly to operate and less water intensive than Once-Through-Steam-Generators (OTSGs). In 2007, Connacher Oil and Gas began operating evaporator technology, which produces a water stream of sufficient quality to permit the switch over to drum boilers, as its main water treatment system. The evaporator and drum boiler combination reduces the water output from the boilers, so called blowdown, from 20 per cent in a WLS/OTSG system, down to three per cent.

The 20 per cent blowdown water stream in a WLS/OTSG system is typically disposed down a well and must be made up with additional water. In the evaporator and drum boiler system the three per cent blowdown is sent back to the evaporator for another pass. Further improvements can be made if zero liquid discharge is the goal by adding a crystallizer to concentrate the water impurities from the evaporator waste into a solid form. This dry solid would then be suitable for environmentally friendly disposal.

"When you’re evaluating the performance level of unconventional resource production, you need to do an apples-to-apples comparison with other oil-producing jurisdictions—with the Middle East, Venezuela, Nigeria. This shows that we’re really first-in-class."

Chris Bloomer, Chief Executive Officer, Connacher Oil and Gas
The future of Canada’s oil sands

“...This is still early days for carbon capture and storage but we’re showing that large-scale projects are feasible. The framework and infrastructure to support broader deployment of the technology is now being put in place and this is the indispensable foundation for the future. By 2030 we’ll have moved a very long way forward.”

**James Cleland, General Manager of Heavy Oil Solutions, GE**

“Oil sands exist because of innovation and by 2030 you’ll witness this innovation accelerating to a level that is an order of magnitude higher and faster. And by then thermal in situ producers will likely have a footprint that is similar to conventional.”

**David Onderwater, Manager Heavy Oil Technology Development, Shell Canada**

“In the not-so-distant future the oil sands industry will become a conventional business. That means a business that is well-defined, well-run, efficient and dramatically different. We’ll have solved many of the issues that we’re talking about right now.”

**Don Verdonck, Executive Senior Vice President, Brion Energy**

“...The status quo is unacceptable. We need to work collectively to unlock challenging oil resources in a way that makes Canadians proud. Innovative thinking and new technologies will enable our industry to develop resources economically, environmentally and socially responsibly.”

**Harbir Chhina, Executive Vice President Oil Sands, Cenovus Energy Inc.**

“I see the day when new technologies and innovation will further unlock the oil sands, making it the world’s largest oil reserve.”

**James Cleland, General Manager of Heavy Oil Solutions, GE**

“Reservoir characterization is advancing rapidly and keeping pace with innovation in extraction technologies. In the future you’ll see companies capable of really fine-tuning production tools and practices to more precisely fit the unique qualities of their reservoirs. What we do today will look clumsy in comparison.”

**Merle Johnson, Chief Operating Officer, Connacher Oil and Gas Limited**
“In the future you’ll see made-in-Alberta innovation providing solutions to the world.”

DAN WICKLUM, CHIEF EXECUTIVE OFFICER, CANADA’S OIL SANDS INNOVATION ALLIANCE

“There is a great deal of excitement and focus on opportunities to improve efficiencies on the in situ side of our industry, but the story on mining extraction technologies has not played out yet – not by a long shot.”

MIKE KRAYACICH, VICE PRESIDENT, OIL SANDS AND IN-SITU TECHNICAL AND RELIABILITY, SUNCOR ENERGY INC.

“In the future you’ll probably see the falling of many more walls and barriers, leading to greater transparency, greater collaboration. What COSIA is pushing with the Water Technology Development Centre is a kind of plug-and-play commercialization of technologies and it shows what’s possible. With more and more joint industry projects you’ll really see accelerating activity, accelerating performance.”

SIMON DAVIES, MANAGER THERMAL DEVELOPMENT, CANADIAN NATURAL RESOURCES LIMITED

“It’s going to be astounding how far we’ll have come in 10 years. By then in situ combustion will have finally come of age.”

BOB GERWING, GENERAL MANAGER ENGINEERING, ATHABASCA OIL CORPORATION

“To conceptualize the oil sands technology of tomorrow you don’t need to look out for radical breakthroughs. Think about the internal combustion engine—it’s come light years in 20 years. In 20 years from today, continuous and incremental advances will have improved existing production technologies in the same way.”

CHRIS BLOOMER, CHIEF EXECUTIVE OFFICER, CONNACHER OIL AND GAS LIMITED

“Many future leaps in oil sands innovation are likely to owe much to the re-combination of current knowledge and technologies in new applications. I’m thinking about the way MEG combined gas injection with the drilling of infill wells to develop eMSAGP [Enhanced Modified Steam and Gas Push] — this is a trend you should watch.”

CHI-TAK YEE, SENIOR VICE PRESIDENT, RESERVOIR AND GEOSCIENCES, MEG ENERGY CORP.

“There are an estimated nine trillion barrels of oil in depleted heavy oil reserves around the world. You’re going to see more companies revisiting these abandoned reservoirs with sophisticated technologies and bringing them back to life.”

JOHN D. WRIGHT, CHAIRMAN, PETROBANK ENERGY & RESOURCES LTD.
Canada’s oil sands: the facts

The extraction, processing and transportation of oil sands bitumen are “capital intensive” activities, involving large capital outlays for equipment and structures. This generates economic activity throughout Alberta and Canada.

Of the total proven reserves, about 20% is recoverable by surface mining methods. The remaining 80% is below a 75-metre threshold and lends itself to extraction by so-called in situ methods (drilling).

In 2012, Alberta’s total bitumen production = 1.9 million barrels per day. Surface mining = 48%, in situ = 52%.
In 2012, about 58% of the bitumen produced in Alberta was upgraded in Alberta.

Oil sands investment surpassed CA$21 billion in 2011 and was CA$27.2 billion in 2012.

According to Alberta’s Ministry of Energy, there were five mining projects and 122 in situ projects operating in Alberta as of January 2013. By 2021, crude bitumen production is expected to reach 3.7 million barrels per day.

Source:
Canadian Association of Petroleum Producers (CAPP)
Innovation surge sparks oil sands opportunities
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