INNOVATION & COLLABORATION

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Cover middle photograph: An irregular-shaped grain and pore micro model showing displaced oil by water (courtesy Farshid Torabi, University of Regina)

PETROLEUM TECHNOLOGY RESEARCH CENTRE (PTRC) 2014-2015 HIGHLIGHTS

- Initial downhole tests were conducted with micro camera technologies, a first step towards imaging wormholes in heavy oil reservoirs.
- A waterflood database is allowing companies in western Canada and as far away as Alaska's North Slope to optimize injection scenarios and improve the use of surfactants and polymers.
- Aquistore is the world's first project injecting CO₂ from a coal-fired power plant, and the first in Canada to inject CO₂ into a deep saline formation. Its measurement and monitoring program includes collaborators from around the world — England, Scotland, Japan, and the United States. Its research work has applications to many other industries.
- PTRC's SaskCO₂USER project is expanding on the rich dataset from the IEAGHG Weyburn-Midale CO₂ Monitoring and Storage Project to help inform regulators and companies on transitioning CO₂enhanced oil recovery projects into long-term storage.

BRIDGING THE GAP FROM BASIC RESEARCH TO SOLVING INDUSTRY'S PROBLEMS — THAT IS WHAT WE DO!

MESSAGE FROM THE CEO



The past year in Saskatchewan's oil patch has seen highs and lows. While oil production hit an all-time high, the price of a barrel of oil has fallen by half in just the last six months of fiscal year 2014-15. It could be argued that the halving of global oil prices has been, in part, a measurement of the success of improved production methods in jurisdictions like Saskatchewan, Alberta, and North Dakota where better extraction methods in heavy oil and Bakken tight oil have added to the domestic supply growth in North America. The PTRC has contributed to improving these recovery technologies over the past 17 years with industry-directed research into vapour extraction and waterflooding in heavy oil reservoirs, and the use of solvents like CO₂ in the Weyburn and Midale fields in the southeast.

A victim of our own success? Hardly. The PTRC's goals have always been two fold — to increase recovery rates from Saskatchewan and Canada's difficult-to-exploit oil reservoirs and to lessen the environmental footprint of recovery by effecting technological and scientific advancements. These goals are arguably more important today in a climate of reduced oil prices.

Reduced prices provide an inpetus to increase production through enhanced oil recovery techniques from existing wells rather than drill new wells. On average an oil well in the heavy oil regions of Lloydminster recovers about 8% of the original oil-in-place. By developing enhanced recovery techniques applicable to watered-out or suspended wells, exploration and production companies can avoid millions of dollars in new capital expenditures.

PTRC's work on solvent recovery, including the use of CO₂, has led to direct commercial applications in some of Husky Energy's heavy oil wells that had completed their primary recovery. Our waterflood database, developed in league with the Saskatchewan Research Council, has been instrumental in providing data to improve waterflood recovery regimes in BP Alaska's North Shore wells.

PTRC remains at the forefront of CO₂ storage measurement and monitoring technologies with Aquistore, part of the world's first integrated carbon capture and storage (CCS) project from a coal-fired power plant (SaskPower's Boundary Dam). In 2014-15 Aquistore continued its baseline studies ahead of CO₂ injection in the spring of 2015, held a second public open house, and completed work on installing a new 1.5 million dollar seismic tool with Japan Oil, Gas and Metals National Corporation (JOGMEC). The learnings and innovative measurement methods at the site will be important not just for CCS projects globally, but for potential application to oil and gas field characterization.

Innovation and collaboration are the two concepts that have defined the 17 years of research successes at the PTRC. We continue to work collaboratively with the Saskatchewan Research Council, the universities of Regina, Saskatchewan, Alberta and Calgary, and work with our industry sponsors to identify and foster research that will have the most impact.

PTRC excels at getting the most out of Canada's oil reserves in a period that requires heightened efficiencies and mitigation of environmental impacts. Together with our corporate and government sponsors, we are moving forward in 2015-16 with a renewed focus on research to improve recovery from heavy and tight oil reservoirs. I'd like to personally thank our Board of Directors, researchers and funders for their commitment and support.

Ken From, CEO Petroleum Technology Research Centre

MESSAGE FROM THE BOARD CHAIR



According to the Saskatchewan Ministry of the Economy, 2014 saw an estimated 30,750 active oil wells producing on average 520,000 barrels of oil per day, making Saskatchewan the sixth largest producer of oil in North America, and the second largest producer in Canada.

A driving force in this total is that Saskatchewan has one of the best investment climates and regulatory regimes in the world when it comes to the development of oil and gas reservoirs. But even a favourable business climate faces challenges where a significant amount of the province's crude is difficult to access (either heavy in sandy reservoirs along the border with Alberta, or tight in formations like the Bakken). Improving low recovery rates remains a pressing concern for both governments and industry alike.

PTRC-funded research has been invaluable for improving recovery rates and for mitigating some of the environmental impacts of oil recovery. In this year's annual report (2014-15) the company continues to demonstrate the broadening effects of its 17 years of advanced research and development projects in both enhanced oil recovery and CO₂ measurement, monitoring and storage.

This past year saw continued successes in PTRC's Heavy Oil Research Network (HORNET) with field trials of wormhole characterization and continuing research projects on improving waterflood and the use of polymers and surfactants.

In addition, the PTRC was approached by the United States Department of Energy to extend the work completed in the IEAGHG Weyburn-Midale CO₂ Monitoring and Storage Project by using that project's data to better inform prospective CO₂ enhanced oil recovery (EOR) operators and government regulators on how to maintain the safety and integrity of CO₂ storage, improve the efficiency of CO₂-EOR operations, and limit liabilities and risks during operations. Aquistore is another flagship scientific project for the PTRC looking at measuring and monitoring the injection and storage of CO₂ into a deep saline formation in southeastern Saskatchewan. This year saw the installation of new seismic technologies from Japan Oil, Gas and Metals National Corporation (JOGMEC) to complement the DAS (distributed acoustic sensing) line in the project's monitoring well. With CO₂ now flowing from SaskPower's Boundary Dam carbon capture facility to the nearby Weyburn oilfield, injection of CO₂ into the Aquistore well is anticipated for the spring of 2015.

As Chair of the Board at PTRC, and Manager of EOR, Planning and Land for Husky Energy's Heavy Oil and Gas Business Unit, I can attest to the impact of PTRC's research on Husky's recovery projects in Alberta and Saskatchewan, which use CO₂ and other solvents to improve heavy oil recovery.

PTRC continues to develop and mentor the next generation of province's research scientists, geologists and engineers through its funding of research organizations and universities like the Saskatchewan Research Council, the University of Regina and the University of Saskatchewan. I would like to take this opportunity to thank my fellow board members, the PTRC's CEO Mr. Ken From, and the excellent staff of the PTRC for jobs well done in helping to solidify Saskatchewan's reputation as a leader in oil and gas R&D.

Brian Watt, Board Chair Petroleum Technology Research Centre

PTRC RESEARCH HAS BEEN INVALUABLE FOR IMPROVING RECOVERY RATES AND FOR MITIGATING SOME OF THE ENVIRONMENTAL IMPACTS OF OIL RECOVERY. THE PTRC IS GOVERNED BY A BOARD OF DIRECTORS COMPRISING REPRESENTATIVES OF THE FOUNDING PARTNERS AND INDUSTRY LEADERS OPERATING IN WESTERN CANADA.

PTRC BOARD OF DIRECTORS AND STRUCTURE

The Petroleum Technology Research Centre (PTRC) is a not-for-profit corporation founded in 1998 by the Government of Saskatchewan, the Government of Canada (Natural Resources Canada), the University of Regina, and the Saskatchewan Research Council. It is located in the Innovation Place Research Park in Regina, Saskatchewan, adjacent to the University of Regina campus.

The PTRC is governed by a Board of Directors comprising representatives of the founding partners and industry leaders operating in western Canada.

VISION AND MISSION

The vision of the PTRC is to be the organization of choice for collaborative petroleum research in Saskatchewan and Canada. Its mission is to initiate and deliver research programs to enhance the efficiency of oil and gas production. PTRC will achieve this vision by leveraging governmental support with industry expertise, harnessing the capability and capacities of research providers. PTRC will focus on research themes that serve as the foundation for a series of research initiatives and projects.

These themes include:

- Heavy oil
- CO₂ storage and CO₂-EOR
- Light oil/tight oil

BOARD OF DIRECTORS 2014-2015 Brian Watt, Chair

Manager, EOR, Planning and Land, Heavy Oil & Gas Business Unit Husky Energy

Randy Brunet

Partner MacPherson, Leslie and Tyerman

Michael Crabtree

Vice-president Energy Saskatchewan Research Council

Esam Hussein

Dean of Engineering and Applied Sciences University of Regina

Bill Jackson

Independent Director

David Payne

Vice-president Exploitation East Canadian Natural Resources Limited

Hal Sanders

Assistant Deputy Minister Minerals, Lands and Resource Policy Division Saskatchewan Ministry of the Economy

Robert Scammell Independent Director

David Grier Chief Strategist

Innovation Saskatchewan

Martin Aube

(Non-voting Director) Director General Energy Innovation Natural Resources Canada

MEETING THE CHALLENGES



A piece of Bakken siltstone, imaged at the CT facilities at the Canadian Light Source in Saskatoon. The light blue areas show the pore space in the rock.

Heavy Oil

Mannville

Saskatchewan's oil and gas industry has flourished in the last 15 years allowing the province to become the second largest producer of oil in Canada and sixth largest in North America. The province has almost 31,000 active oil wells in five main oil producing regions — heavy oil production from the Mannville along the western side of the province, the Shaunavon medium oil play in the southwest, the light/tight oil Bakken in the southeast, the light/tight Viking play in west central, and the light/medium Mississippian oil plays also in the southeast.

The total value of the oil produced in 2014 was close to 16 billion dollars. Over 38,000 people — both directly and indirectly — were employed in the oil and gas sector, and 1.6 billion dollars was paid to the province through land sales and royalties.

But of the estimated 54 billion barrels of oil-in-place in Saskatchewan, less than 13% is recoverable using existing technologies. If just heavy oil is considered, recovery rates drop as low as 6 or 7%, meaning that 93% of the oil remains unproduced.

As of late 2014, recoverable oil reserves in Saskatchewan totalled only 1.3 billion barrels. New technologies can maintain or extend

those barrels of reserves as new methods are developed to better maximize recovery, helping to reduce new expenditures, which is particularly important in the face of fluctuating commodity prices.

The challenges faced by Saskatchewan to maximize oil recovery, while reducing costs and environmental impacts, parallel many of those faced by other oil producing areas of Canada and the world.

Watered-out and Worm-holed Reservoirs

Because heavy oil in the Mannville region is contained in sandy reservoirs that require the production of sand, oil, and water, many wells are unable to maintain pressure and production capabilities when channels open in the reservoirs between the injection and production wells. These "wormholes" lead to steep declines in production and the need to drill more wells.

As of 2014, there were an estimated 16,000 heavy oil wells in Saskatchewan that were non-active or suspended because of declining production rates related to wormholed reservoirs. PTRC is working on technologies to re-establish production from these suspended wells.

Utilizing Saskatchewan's CO₂

With the opening of SaskPower's Boundary Dam Carbon Capture facility in 2014, an important supply of carbon dioxide (CO₂) became available for enhanced oil recovery, and Cenovus Energy's Weyburn oilfield began accepting CO₂ from Boundary Dam this past year. PTRC's Aquistore project is looking at measurement and monitoring technologies in relation to the storage of CO₂ from Boundary Dam in a deep saline formation, and has further extended research into transitioning CO₂-EOR operations into long-term storage in its SaskCO₂USER project. The importance of CO2 as a solvent in different kinds of oil reservoirs is an important area of research for both Saskatchewan and the world.

Better Efficiencies in Changing Economic Times

With the fall in oil prices, methods of recovery in the oil patch need to become more efficient and result in prolonged recovery periods. The only way to meet this challenge is through improved recovery processes and EOR technologies. PTRC is meeting this challenge head-on.

Diagram courtesy Geoscape Southern Saskatchewan and Saskatchewan Ministry of the Economy

Viking Oil

THE CHALLENGES FACED BY SASKATCHEWAN TO MAXIMIZE OIL RECOVERY WHILE REDUCING COSTS AND ENVIRONMENTAL IMPACTS PARALLEL MANY OF THOSE FACED WORLDWIDE.

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PTRC HAS RECOGNIZED, FROM ITS INCEPTION, HOW INNOVATIONS IN ONE FIELD CAN FOSTER SOLUTIONS IN MANY OTHERS.

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INNOVATION



Opposite Page: Microsensor motes similar to those injected into reservoirs in PTRC's wormhole research (image courtesy INCAS³).

Above Top: One of the drill bits used to drill the Aquistore well.

Above Bottom: A rendering of a micro-camera being sent down a well bore.

Innovations in one field of endeavour can foster solutions in many others. The Aquistore Project is one such PTRC success story. Although CO_2 injection had not yet begun at the site by the end of fiscal year 2014-15, the two deepest wells ever drilled in Saskatchewan and the world-leading measurement and monitoring tools already at work have created cross-industry interest for the potential application of these emerging technologies outside of CO_2 storage.

The observation well at the Aquistore site includes a DAS (distributed acoustic system) fibre line capable of providing seismic imaging of the formation from depths of over 3 km. In addition to the permanent seismic array at the surface of 650 geophones — the largest set-point tool ever deployed for measuring seismic activity at a CO₂ storage site — Aquistore's use of the DAS line has drawn the attention of oil and mining companies that are examining more efficient means for seismic imaging of fluids in reservoirs.

Aquistore partners have also deployed a permanent seismic source called the Accurately Controlled and Routinely Operated Signal System, or ACROSS. This \$1.5 million installation, one of just three in the world, will provide a source for seismic measurement devices at the site. Data produced through the use of this system may be helpful well beyond CO₂ injection, with application to oil and gas industries.

Aquistore's experience is also sought for advice on public outreach and consultation. Late 2014 saw the second open house in the city of Estevan focusing on disseminating the baseline monitoring results for the project ahead of actual CO_2 injection — and a third open house for the general public is planned in 2015-16 to report on the initial scientific findings of injection. A project further examining the data from the completed Weyburn-Midale Project funded by the United States Department of Energy and the Government of Saskatchewan — began work in late 2014. The Saskatchewan CO₂ Oilfield Use for Storage and EOR Research, or SaskCO₂USER, will be informing CO₂-enhanced oil recovery operations on what is required to turn those oilfields into long-term storage operations both from a technological and safety prospective, and for potential storage credit at a future date.

PTRC's project of mapping of wormholes in heavy oil reservoirs continued to advance in the Heavy Oil Research Network (HORNET) in 2014-15 with a second field test using downhole camera pills to see if images of wormholes in the immediate areas outside of the well could be visualized and relayed back to the surface in real-time. Additional tests of new technologies for imaging wormholes are planned for the coming year.

PTRC has also advanced work on imaging the formation of foamy oil under reservoir conditions utilizing the synchrotron at the Canadian Light Source in Saskatoon. These multi-disciplinary research projects will help operators determine the best practices for oilfield depressurization during cold heavy oil production.

COLLABORATION





Opposite Page: Dr. Mingze Dong of University of Calgary with doctoral student Haiyan Zhang.

Above Top: Dr. Peter Gu works on PTRC research projects at the University of Regina.

Above Bottom: Junior high school students from Regina joined PTRC and SaskPower at a science fair in Regina.

PTRC has excelled at developing projects that put the best researchers and private sector partners together to solve industry problems. When the IEAGHG Weyburn-Midale CO₂ Monitoring and Storage Project came to an end in 2012, five governments and ten private companies had funded the research program, and more than 30 universities, research councils and organizations had conducted work and contributed toward the project's findings. That extensive network of researchers and companies continues to expand with our new and ongoing projects.

The Heavy Oil Research Network (HORNET) is an industry-driven research program that has seen projects conducted by the University of Regina, Saskatchewan Research Council, University of Calgary, and the University of Alberta in 2014-15. The PTRC has put these researchers in contact with other organizations not typically in the oil and gas sector — such as the Canadian Light Source in Saskatoon — which is working with the University of Calgary to image the formation of foamy oil under reservoir conditions as part of a broader enhanced oil recovery research project.

The Aquistore project's extensive measurement, monitoring and verification program has attracted international researchers from the United Kingdom, Japan, Korea and the United States. PTRC has also been facilitating the UK Carbon Capture and Storage Institute on separate work looking at tracers in the transported CO₂. Finally, PTRC also played an active role in educating the next generation of researchers by sponsoring the Educating Youth in Engineering and Science Program at the Unviersity of Regina, and co-sponsoring a research workshop in CO₂ for junior high school students at Regina's Science Centre.

Other international organizations have also been working with the PTRC in the SaskCO₂USER project. England's University

of Bristol continued to conduct passive seismic measurements at the Weyburn oil field as part of the project, and history matching work progressed through the Netherland's Association for Applied Research (TNO) which is looking to develop a better storage model through time lapse seismic data combined with flow simulations of reservoir porosity and permeability. The Energy and Environmental Research Centre (EERC) located at the University of North Dakota is looking into causes and prevention methods of well casing corrosion, the annual cost of which is estimated at \$1.4 billion for oil and gas operators in the United States alone. Another U.S. collaborator, the Gulf Coast Carbon Center at the Bureau of Economic Geology, University of Texas (Austin) is examining the minimum data set required to assure the safe storage of CO₂ in an oil reservoir.

The PTRC also hosted a tight oil symposium in March 2015 in Calgary, Alberta, jointly sponsored by Natural Resources Canada. That symposium attended by over 80 researchers and oil company representatives — included speakers from Saskatchewan Research Council (SRC), the Universities of Calgary and Saskatchewan, and groups from the United States such as the Department of Energy, the North Dakota Geological Survey and the EERC. It marked the beginning of a planned expansion by PTRC into light/light enhanced oil recovery for 2015-16. PTRC HAS EXCELLED AT DEVELOPING PROJECTS THAT HAVE PUT THE BEST RESEARCHERS AND PRIVATE SECTOR PARTNERS TOGETHER TO SOLVE INDUSTRY PROBLEMS.

NAND INTERFACIA

To the Members, Petroleum Technology Research Centre Inc.

The accompanying summary consolidated financial statements, which comprise the summary consolidated statement of financial position as at March 31, 2015, and summary consolidated statements of operations and cash flow for the year then ended and related notes, are derived from the audited financial statements of Petroleum Technology Research Centre Inc. for the year ended March 31, 2015. We expressed an unmodified audit opinion on those financial statements in our report dated July 16, 2015.

The summary financial statements do not contain all the disclosures required by Canadian accounting standards for notfor-profit organizations. Reading the summarized financial statements, therefore, is not a substitute for reading the audited financial statements of Petroleum Technology Research Centre Inc.

Management's Responsibility for the Summary Consolidated Financial Statements

Management is responsible for the preparation of a summary of the audited financial statements in accordance with Canadian accounting standards for not-for-profit organizations.

Auditor's Responsibility

Our responsibility is to express an opinion on the summary financial statements based on our procedures, which were conducted in accordance with Canadian Auditing Standards (CAS) 810, Engagements to Report on Summary Financial Statements.

Opinion

In our opinion, the summarized consolidated financial statements derived from the audited financial statements of Petroleum Technology Research Centre Inc. for the year ended March 31, 2015 are a fair summary of those financial statements, in accordance with Canadian accounting standards for not-for-profit organizations.

Regina, Saskatchewan July 16, 2015

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Chartered Professional Accountants

SUMMARY CONSOLIDATED STATEMENT OF FINANCIAL POSITION FOR THE YEAR ENDED MARCH 31, 2015

(C\$000s)		2015		2014
Assets				
Cash	\$	7,181	\$	4.623
Other assets	Ŷ	2,583	Ŧ	4,029
Total assets		9,764		8,652
Liabilities and net assets				
Deferred revenue		6,787		7,564
Other liabilities		1,140		286
Total liabilities		7,927		7,850
Net assets		1,837		802
Total liabilities and net assets	\$	9,764	\$	8,652

SUMMARY CONSOLIDATED STATEMENT OF OPERATIONS AND UNRESTRICTED NET ASSETS FOR THE YEAR ENDED MARCH 31, 2015

(C\$000s)		2015		2014
Revenue				
Government of Canada funding	\$	276	\$	1.690
Government of Saskatchewan funding	Ŧ	2.824	т	4,108
Industry funding		1.776		7.535
Other funding		705		836
Total revenue		5,581		14,169
Expenses				
Projects		2,660		4,942
Operations		1,886		3,255
Total expenses		4,546		8,197
Excess of revenue		1,035		5,972
Unrestricted net assets (deficit), beginning of year		802		(5,170)
Unrestricted net assets, end of year	\$	1,837	\$	802

SUMMARY CONSOLIDATED STATEMENT OF CASH FLOWS FOR THE YEAR ENDED MARCH 31, 2015

(C\$000s)	2015	2014
Net cash from (used in) operating activities	\$ 2,559	\$ (3,920)
Net cash used in investing activities	(1)	-
Increase (decrease) in cash	2,558	(3,920)
Cash, beginning of year	4,623	8,543
Cash, end of year	\$ 7,181	\$ 4,623

1. Summary financial statements

The summary financial statements are derived from the audited financial statements, prepared in accordance with Canadian accounting standards for not-for-profit organizations, as at March 31, 2015 and for the year then ended.

The preparation of these summary financial statements requires management to determine the information that needs to be reflected in them so that they are consistent in all material respects with, or represent a fair summary of, the audited financial statements.

Management prepared these summary financial statements using the following criteria:

- (a) the summary financial statements include a statement for each statement included in the audited financial statements;
- (b) information in the summary financial statements agrees with the related information in the audited financial statements;
- (c) major subtotals, totals and comparative information from the audited financial statements are included; and
- (d) the summary financial statements contain the information from the audited financial statements dealing with matters having a pervasive or otherwise significant effect on the summarized financial statements.

The audited financial statements of Petroleum Technology Research Centre Inc. are available upon request by contacting the Centre.

COLLABORATIONS

Bissett Resource Consulting Perm Inc. **BP** Alaska Canadian Natural Resources Limited Carbon Capture Project 3 Chevron **Consumers Co-operative Refinery Limited** Devon Canada Enbridge SaskEnergy **Energy and Environmental** Research Centre (EERC) SaskPower EV - The Well Diagnosis Company Schlumberger FMC Technologies GeoForschungsZentrum (GFZ) Scintrex Geological Survey of Canada Scottish CCS Global Carbon Capture and Storage Institute Golder and Associates GroundMetrics Harris Corporation Husky Energy Illinois Basin – Decatur Project IEAGHG IEAEOR INCAS³ Innovation Saskatchewan Institut national de la recherche scientifique (INRS) Japan Oil, Gas and Metals National Corporation (JOGMEC) Korea National Oil Corporation Lawrence Berkley National Labs (USDOE) Natural Resources Canada **Outerlimits Geophysics** Weatherford OYO Corporation (Japan)

Plains CO₂ Reduction Partnersip (PCOR) Research Institute of Innovative Technology for the Earth (RITE) Saskatchewan Geological Survey Saskatchewan Ministry of Environment Saskatchewan Ministry of the Economy Saskatchewan Research Council Schlumberger Carbon Services St. Francis Xavier University Sustainable Development Technologies Canada (SDTC) The Netherland's Association for Applied Research (TNO) **TIPM Laboratory UK CCS Research Centre** United States Department of Energy (USDOE) University of Alberta University of Bristol University of Calgary University of Ottawa University of Regina University of Saskatchewan University of Strathclyde University of Texas - Bureau of Economic Geology



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