

BUILDING ON ALBERTA'S STRENGTHS

IN ENERGY AND ENVIRONMENT







“THE NEW ALBERTA INNOVATES WILL DELIVER 21ST CENTURY SOLUTIONS TO THE MOST COMPELLING CHALLENGES FACED BY ALBERTANS. WE WILL SUPPORT OUR WORLD-CLASS RESEARCHERS, ENTREPRENEURS AND INDUSTRY INNOVATORS AS WE WORK TOGETHER TO CREATE JOBS, DIVERSIFY OUR ECONOMY AND DEMONSTRATE CLIMATE LEADERSHIP. WITH OUR PARTNERS, WE WILL BUILD A COORDINATED, RESPONSIVE AND STRONGER RESEARCH AND INNOVATION SYSTEM – ONE THAT CAN TAKE ALBERTA TO THE GLOBAL STAGE.”

JUDY FAIRBURN, CHAIR OF THE BOARD

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MESSAGE FROM THE BOARD CHAIR



WITH OUR PARTNERS,
WE WILL BUILD
A COORDINATED,
RESPONSIVE AND
STRONGER RESEARCH
AND INNOVATION
SYSTEM – ONE THAT
CAN TAKE ALBERTA TO
THE GLOBAL STAGE.

On behalf of the Alberta Innovates Board, I am pleased to present the final Report on Outcomes for Alberta Innovates - Energy and Environment Solutions (AI-EES).

On November 1, 2016, AI-EES was one of four discipline-based corporations consolidated into Alberta Innovates. The new Alberta Innovates will deliver 21st century solutions to the most compelling challenges faced by Albertans. We will fund and drive provincial research and innovation — building on Alberta’s strengths in environment, energy, health, food, forestry/fibre, and emerging technology sectors. We will support our world-class researchers, entrepreneurs and industry innovators as we work together to create jobs, diversify our economy and demonstrate climate leadership. With our partners, we will build a coordinated, responsive and stronger research and innovation system — one that can take Alberta to the global stage.

This year, our Clean Energy team (formerly called Energy and Environment Solutions) worked alongside our partners, making world-leading efforts to improve water efficiency in the energy industry, reduce greenhouse gas and methane emissions and advance technology that will speed up the reclamation of tailings ponds. To meet the need of partners in the water sector, we initiated multi-stakeholder projects to improve basin-wide water management. New modelling and forecasting tools will help Alberta better adapt to stressors on our water system, such as population growth, our changing economy and shifts in climate.

I am proud of what the Clean Energy team has achieved this year. Their dedication to understanding the challenges in the energy and environment sectors, and working with partners to help them meet their goals is a tangible demonstration of what we can achieve when we work together. In 2016-2017, we will accelerate research and innovation to deliver even stronger results to Albertans.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Judy Fairburn', with a long horizontal line extending to the right.

Judy Fairburn, Chair of the Board

MESSAGE FROM THE VICE PRESIDENT, CLEAN ENERGY



It has been a very good year. The evolution to become one innovation powerhouse — Alberta Innovates — will allow our partners to more easily tap into our collective, multi-sector strengths. Going forward, the AI-EES team, becomes Alberta Innovates' Clean Energy group. I am fortunate to now serve this team as Vice President.

The strategic areas within our clean energy portfolio have not changed as a result of consolidation, however, we will broaden our connections within the AI system and stretch beyond our 2030 targets with a view on 2050. Our new cross-sector approach will also enable our partners to take advantage of innovation across the food, fibre, health, energy, environment, and technology development spectrum, to advance the clean energy agenda.

In this Report on Outcomes, we share nine of our most recent success stories. Highlights include an update on how:

- » A novel technology called ESEIEH (Enhanced Solvent Extraction Incorporating Electromagnetic Heating) is taking the steam out of in situ bitumen recovery
- » The EKS tailings reduction technology is moving from a small pilot to commercial-scale demonstration, quickening the pace of future reclamation efforts
- » Integration of the Molten Carbonate Fuel Cell (MCFC) with oil sands facilities has the potential to increase energy efficiency and significantly lower carbon capture costs
- » New peat moss studies challenge contemporary thinking on heavy metal levels upstream of Fort McMurray and downstream from industry
- » Five Alberta municipalities are benefitting from new research that shows the potential to produce heat and power from nearby geothermal resources.

This summary of work provides only a snapshot of the 81 projects and \$12.5 million invested in breakthrough initiatives that will change the game for Alberta. Our experts continue to be called upon to speak at forums around the world and share insight into the world-class research and technology development that is taking place in our province.

We have a powerful story to tell, and as Albertans we can all be proud of the steps being taken to further develop clean energy and reduce industry's impact on the environment — whether that means improvements to water efficiency, methane and greenhouse gas emissions reductions or new developments in value-added initiatives that will see only the cleanest energy products go to market.

Sincerely,

A handwritten signature in black ink, appearing to read "John Zhou". The signature is fluid and cursive.

John Zhou, PhD, Vice President Clean Energy

OUR NEW CROSS-SECTOR APPROACH WILL ALSO ENABLE OUR PARTNERS TO TAKE ADVANTAGE OF INNOVATION ACROSS THE FOOD, FIBRE, HEALTH, ENERGY, ENVIRONMENT, AND TECHNOLOGY DEVELOPMENT SPECTRUM, TO ADVANCE THE CLEAN ENERGY AGENDA.

2015–2016 HIGHLIGHTS

ENERGY TECHNOLOGIES

Bitumen Value-Added

- » Completed Phase 2 of the Oil Sands Competitiveness study with participation by the Federal government, the governments of Alberta and Saskatchewan and six companies. The study concluded that partially upgraded bitumen (PUB) will increase the overall value of Athabasca bitumen and that PUB products will be broadly accepted in global crude oil markets. The most attractive markets are refineries in China, the U.S. Gulf Coast, and Europe. Partially upgraded bitumen mitigates pipeline access to North American markets by reducing diluent requirements, but the need for additional high-capacity access to tidewater is necessary to reach other valuable markets.
- » Initiated two additional phases of the Oil Sands Competitiveness study:
 - Phase 3 will determine the market for partially upgraded bitumen in refineries in Eastern Canada.
 - Phase 4 will estimate the GHG emission impact of refining partially upgraded bitumen.
- » Signed a Letter of Understanding with Natural Resources Canada to establish the development and joint funding of a bilateral strategic environmental and energy research program. This collaborative program will address issues in a number of areas important to Alberta and Canada, including partial upgrading. Under the National Partial Upgrading Program (NPUP), Alberta Innovates:
 - Completed a white paper that reviewed the state of partial upgrading to identify technology gaps that need to be addressed through research and development. The results have been used to provide strategic direction to the NPUP.
 - Conducted a workshop to engage industry participants in the direction and funding of the program. A core steering group of six companies has been established to advance partial upgrading technology. As a result of the workshop, additional companies are considering participation in the program and a second workshop with potential technology providers is scheduled.

- » Supported research projects at CanmetENERGY and Alberta universities to build a platform for future partial upgrading technologies through industrial chairs in bitumen upgrading and petroleum thermodynamics.
- » Continued to support the Institute for Oil Sands Innovation (IOSI) at the University of Alberta. IOSI conducts proof-of-concept research focused on bitumen upgrading and characterization, non-aqueous extraction technologies, tailings process fundamentals, and online instrumentation for oil sands.
- » Managed, on behalf of Emissions Reduction Alberta (ERA) (formerly called CCEMC), two multimillion dollar/multiyear pilot projects of partial upgrading technology. Other projects managed on behalf of ERA included piloting a low cost oxy-fuel technology to capture CO₂ from a once-through steam generator for in situ oil sands extraction, and converting waste CO₂ into high value products such as Dimethyl Carbonate.
- » Completed a project examining the efficacy of visbreaking bitumen using acidic compounds to improve its quality. The project tested several acids but the results indicated little or no benefit for partial upgrading. This line of research has been discontinued.

Advanced Recovery

- » Managed, on behalf of ERA, three multimillion dollar/multiyear demonstration projects involving pilots applying solvents and electro-magnetic heating to recover in situ bitumen.
- » Supported research projects at universities to build a platform for next generation recovery technologies through industrial research chairs in oil sands engineering, reservoir geomechanics, reservoir simulation, and petroleum microbiology. A novel process developed through the Oil Sands Engineering Chair, the Hybrid Bitumen Extraction Process (HBEP), is being piloted at CanmetENERGY in Devon.
- » Initiated a project to determine the behavior of hydrocarbons in nanochannels and improve understanding of transport in shales.

2015–2016 HIGHLIGHTS

- » Continued to support enhancing oil sands operations through InnoTech Alberta's (formerly called AITF) AACI program.

Natural Gas Value Add

- » Completed the second phase of a study regarding new modular gas-to-liquid (GTL) technologies to convert low value natural gas to high value products. The Ministries of Energy and Economic Development and Trade also participated. Based on preliminary technical and economic feasibility, the study concluded that there are several promising technologies at or close to the demonstration stage.
- » The CarbonSaver Technology pilot to produce hydrogen directly from natural gas was terminated due to financial difficulties for the developer.

RENEWABLES AND EMERGING TECHNOLOGIES

Waste-to-Value-Added

- » The Enerkem Alberta Biofuels commercial facility initiated the production of bio-methanol from municipal solid waste in Edmonton. A \$40 million ethanol module is being added and ethanol production is expected to begin in 2017. Alberta Innovates collaboration in this facility dates back to 2004.
- » Hosted a biogas stakeholder workshop to identify barriers that hinder the development of biogas industry in Alberta. A key outcome was the development of a White Paper to identify an action plan to promote the biogas industry.
- » To address information gaps for converting waste into valuable products:
 - Completed an Alberta Biowaste Inventory Study that identified opportunities for establishing waste-to-value-added facilities in rural communities.
 - In collaboration with the Tri-region (Parkland County, City of Spruce Grove and Town of Stony Plain), completed a front-end engineering design study working toward the construction of a showcase facility for converting municipal solid waste (MSW) into valuable products in small urban communities.

- An assessment of the feasibility of establishing a waste conversion facility in the St. Paul region. This study also included the assessment of the amount of MSW generated in the province through the development of GIS maps. It will be used to identify optimal locations for building waste conversion facilities across Alberta.
- Collaborated with the Town of St. Paul and its partners on a front-end engineering design study working toward the construction of a showcase facility for converting municipal solid waste (MSW) into valuable products in small rural communities.
- Supported a University of Calgary feasibility study of using biogas to enhance liquid fuel production through advanced pyrolysis. This project addresses the technology gap for converting dry organic materials from MSW into valuable products.
- » Collaborated with Alberta Environment and Parks to develop scientific information for the greenhouse gas (GHG) generation potential of landfilled wastes. This work will allow the Government to refine its landfill gas GHG quantification protocol.

Clean Power

- » A CO₂-enhanced geothermal study was completed at the University of Alberta to investigate the feasibility of using carbon dioxide as a working fluid for recovering energy from our deep geothermal reservoirs.
- » In collaboration with the University of Alberta, City of Grand Prairie, County of Grand Prairie, Town of Hinton, Municipal District of Greenview and Tri-Council of Clearwater County, Village of Caroline and Town of Rocky Mountain House, a deep-dive geothermal reservoir analysis project was initiated to determine commercial development strategies for the top 10 potential geothermal generation reservoirs in Alberta.
- » Collaborated with a University of Alberta spinoff company, AdvEn Solutions and Lockheed Martin to accelerate the commercialization of a breakthrough battery storage technology with improved performance for lower power electronic devices such as mobile phones.

- » Following a \$2 million Call for Proposals titled “Next-Generation Energy Storage Technologies for Accelerating the Deployment of Intermittent Renewable Electricity in Alberta,” four novel energy storage projects are underway.
- » Partnered with ERA and SOLAS Energy Consulting to undertake a study, Energy Storage and Renewable Energy in Alberta: An Analysis of Potential Greenhouse Gas Emissions Reductions.

Technology Intelligence & Systems Modelling

- » Published a Technology Intelligence Study that identified biological and thermal-based technologies to convert solid organic waste into value-added products at a small rural municipality scale.
- » Initiated a Plasma Gasification Technology Intelligence Study to evaluate the feasibility of converting municipal, industrial and hazardous waste into value-added products.
- » Initiated a Small Modular Nuclear Reactor (SMNR) Technology Intelligence Study to identify existing and emerging SMNR technologies that are deployable by 2030, and capable of satisfying the needs of end-users in Alberta’s oil sands (combined heat and power), electricity market (baseload and non-baseload operation) and remote communities (power, heat and desalinated water production).
- » Completed modelling studies on the assessment of energy efficiency improvement options for Alberta’s pulp and paper and chemical sectors.
- » Completed a comprehensive study on the techno-economic and life cycle assessments of hydrogen production for the oil sands industry from wind power and hydro power.
- » Completed a comprehensive study on the techno-economic and life cycle GHG assessments of the liquefied natural gas (LNG) supply chain from Canada to Asia-Pacific (China, Japan and India). Engineering based models were developed to calculate the production cost, transportation cost and GHG footprint of transporting Canadian LNG to these markets.
- » Completed a comparative study on the techno-economic assessment of coal-to-liquids (CTL) and gas-to-liquids (GTL) technologies in Alberta.

WATER AND ENVIRONMENTAL MANAGEMENT

Water Management

- » Invested in studies in South Saskatchewan River Basin management, source water protection, and water supply as a function of climate variability to ensure a future water supply for a growing population and economy in Alberta.
- » The Government of Alberta implemented recommendations from the report on Climate Vulnerability and Sustainable Water Management in the South Saskatchewan River Basin, including the signing of a five-year agreement between TransAlta and the Government of Alberta to manage water in reservoirs on the Bow River to help flood mitigation efforts and along the Kananaskis River to help drought mitigation efforts.
- » Completed a multidisciplinary project investigating natural and anthropogenic sources of contaminants in the Lower Athabasca River has revealed results that challenge currently held perceptions of water quality in the region.
- » Improved understanding of urban and rural waste water treatment options, and the by-products of water disinfection processes.
- » Research in aquatic ecosystems (rivers and wetlands) is providing information for policy development to protect the health of aquatic ecosystems.
- » Research on groundwater quality baselines, recharge rates, and contamination by arsenic, pesticides and pathogens research is leading to the protection of groundwater quality and sustainable use of groundwater resource.
- » Investments in irrigation demand models, technologies to recycle water in SAGD oil sands facilities, and the treatment of process water from mining operations are placing water use conservation, efficiency, and productivity (CEP) improvements on track to achieve the target of a 30 per cent increase in CEP.

2015–2016 HIGHLIGHTS

- » Three technologies are being demonstrated in the field aimed at reducing the energy requirements for water recycling at thermal in situ oil sands facilities, while maintaining or increasing water recycle rates, in support of water use efficiency and GHG reduction targets.
- » In 2015-16, Alberta Innovates received a five-year \$25 million grant to support activities that address knowledge and technology gaps in support of the Water for Life Strategy. A funding opportunity was announced in 2015-16 that will support new projects in four key investment areas: water supply and watershed management; healthy aquatic ecosystems; water use and efficiency; and water quality protection. Alberta Innovates also initiated a partnership with Sustainable Development Technology Canada (SDTC) that will lead to co-investment in water technology projects worth more than \$12 million in 2016-17.

Knowledge Transfer and Education Initiatives

- » Sponsored Navigate 2016, a youth water summit organized by Inside Education. Navigate brings together youth from across the province to learn about water issues. Students develop projects that they take back to their schools and communities to help improve water use and water quality.
- » Sponsored EnviroAnalysis, which was held for the first time in western Canada. This semi-annual conference responds to a perceived lack of attention to the critical importance of chemical analysis and monitoring in environmental research. AI received the EnviroAnalysis Founders' awards in recognition of their contributions and support of environmental education, communication and technology transfer activities at the 2015 event.
- » Co-sponsored with COSIA a water conference in Calgary, in March 2016. Four hundred delegates attended this event enabling industry, researchers, governments, and the service, supply and technology sectors to advance technology research, development and deployment aimed at environmental performance improvement for water management in the oil sands.

Land Restoration

- » Built a portfolio of projects to enhance the scientific understanding and development of best practices in managing atmospheric deposition, wetlands, land disturbance, ecosystem health, biodiversity conservation, environmental monitoring, and restoration ecology.
- » Supported new research that shows atmospheric deposition rates of metals in north-eastern Alberta seem to be comparable to levels detected in reference and rural settings elsewhere in the world, and are lower than previously reported for the Athabasca oil sands region, with the exception that deposition rates do increase with proximity to the oil sands mines and upgraders.
- » Supported the Alberta Biodiversity Conservation Chair research program, which continues to provide new insights into patterns and abundance of species in Alberta as well as their responses to industrial disturbance and restoration.
- » Supported the University of Alberta's work on linear corridor restoration at multiple spatial scales, which has resulted in regional planning tools now in use by government to understand and prioritize footprints where restoration activities are most likely to result in meeting desired land use objectives (e.g., caribou habitat restoration).

Tailings Management

- » Technologies such as in-line dewatering and electro kinetic settling are being demonstrated to reduce and minimize the generation of mature fine tailings. These studies were completed at the research pilot stage and will be moving to field demonstrations in the next two years.
- » Both Alberta Innovates and the COSIA industry partners committed to support for another five-year term for a NSERC industry research chair to treat tailings water for safe release into the environment.
- » Initiated a project with an industry partner to test the performance of a new ceramic Titania membrane that is touted to better capture solids, organics and some salts in oil sands tailings, all in support of more effective tailings management.

GHG Management

- » Through Alberta Innovates and ERA, nine carbon capture technologies are being developed that offer the potential to reduce carbon capture costs. Five of the technologies are being tested at a field pilot stage and others at laboratory development stages.
- » Through ERA funding, Alberta Innovates assisted technology deployment to reduce fugitive emissions in natural gas production and improve energy efficiency. In total, emission reductions of more than 100,000 t/yr CO₂e were achieved.
- » Since 2012, Alberta Innovates, in partnership with COSIA and other oil sands companies, evaluated the feasibility of using molten carbonate fuel cells (MCFC) for carbon capture at oil sands facilities. Two feasibility studies were completed (2013 and 2015) that indicated MCFCs have the potential for low cost carbon capture and integrate well with thermal in situ oil sand facilities. Alberta Innovates has undertaken a major initiative for a megawatt-scale pre-FEED study to further understand the cost of using MCFC for carbon capture at oil sands facilities.
- » Continued to support the Canadian Centre for Clean Coal/Carbon and Mineral Processing Technology (C5MPT) located at the University of Alberta. The Centre conducts fundamental research in four theme areas: clean coal/carbon, CO₂ storage, mineral processing, and hydrocarbon processing.



SUCCESS STORIES

It traditionally takes 20 to 30 years to take an idea from the lab to commercialization. At Alberta Innovates we aim to accelerate innovation. The measuring of year-by-year results — while an important indicator of progress — does not show the full impact of our investments in research, development and innovation. In 2015-16 we invested \$12.5 million in 81 active projects. The nine stories that follow provide only a glimpse at our annual progress. We ask readers to consider that these stories represent a snapshot in time and the total impact of our work real economic and environmental gains requires long-term monitoring of these specific projects.

NATIONAL PARTIAL UPGRADING PROGRAM – PARTNERSHIPS TO ACCELERATE INNOVATION



IMPACT

The collaborative approach pools national ingenuity and accelerates the development and deployment of partial upgrading technologies. Albertans will benefit from the social and economic benefits of partial upgrading.

FOCUS AREA

Adding value to our energy resources

TARGETS



Securing the most value for our bitumen has been a major focus for Alberta Innovates (AI) for over 10 years. What started as the ‘next generation upgrading’ program has grown into a multi-stakeholder initiative with federal support.

Initiated by AI in 2014, our National Partial Upgrading Program (NPUP) now pools national ingenuity to find the most environmentally-friendly and economically-sustainable ways to get Alberta’s bitumen resources to market.

“Despite the drive toward ‘zero-impact’ energy, oil and gas resources remain an essential part of everyday life,” says Margaret Byl, Executive Director, Energy Technologies, AI. “It is of the utmost importance to produce, process, and transport oil resources in the cleanest and most efficient manner possible. We believe our partial upgrading advancements are a world-leading effort to continue Canada’s direction for providing the most sustainable and competitive oil and gas resources possible to global markets.”

NPUP partners have been supporting academic and industry focused initiatives that accelerate

innovation and provide opportunities to sell Alberta’s bitumen and heavy oil in world markets.

“Our goal is improving product quality, eliminating the use of diluent, and reducing environmental impacts, while maximizing the overall resource value,” says Tom Corscadden, VP Marketing, Engineering and Operations for MEG Energy and NPUP partner.

“What we know is, partially upgraded products have greater value and are more competitive than dilbit in global markets. Partially upgraded bitumen products have lower GHG intensities during refinery processing than dilbit. And processing these products in Western Canada relieves pipeline capacities on a per barrel basis compared to dilbit — which allows for greater volumes to be produced and transported to market for a fixed pipeline capacity,” he adds.



OUR GOAL IS IMPROVING PRODUCT QUALITY, ELIMINATING THE USE OF DILUENT, AND REDUCING ENVIRONMENTAL IMPACTS, WHILE MAXIMIZING THE OVERALL RESOURCE VALUE.

The NPUP is currently supporting a number of ongoing projects, including five at CanmetENERGY, six new projects and three recently completed studies.

One study investigates the feasibility of building an upgrading facility in Alberta. The University of Calgary's, Dr. Jennifer Winters and Dr. Robert Mansell, are completing this work, which examines the social and economic benefits that could be realized from a 100,000 barrel per day partial upgrading facility in the province.

"The partial upgrading technology we examined has a positive private and social net benefit to Alberta," says Winters. "An important part of

the benefit includes the increased value of the partially upgraded product, compared with the original bitumen. A second benefit comes from reduced expenditures on diluent for shipping raw bitumen. A final benefit comes in the form of a reduction in the required pipeline capacity for shipping the partially upgraded product to refiners on the U.S. Gulf Coast."

Winters goes on to say this work builds upon previous studies supported by AI. And while the final quantifiable results from the report are not yet published, she adds the results show there could be a great opportunity for Alberta to move toward building a partial upgrading facility in the province.

NPUP supporters and participants: AI, NRCan, Ministry of Economy – Saskatchewan, CNRL, Husky, MEG, Cenovus, Suncor, Nexen

NPUP PROJECTS IN PROGRESS AT CANMETENERGY:

Develop and assess partial upgrading technologies using pilot plants

Determine partial upgrading limits and predicting fouling tendency, stability and compatibility

Perform modelling, simulation, and optimization and life cycle assessment on GHG emissions

Develop computational tools for molecular simulation of partially upgraded bitumen

Expand capabilities for characterization of bitumen and partially upgraded bitumen

Approved:

Nexen's partial upgrading technology

One-step plasma-assisted technology for manufacturing high performance carbon fibers using asphaltene precursors

Completed:

Assessment of Opportunities for Western Canadian Partially Upgraded Heavy Oil in Canadian Refineries

Assessment of Partially Upgraded Bitumen GHG Emissions at Refineries

Public Interest Benefit Evaluation of Partial Upgrading Technology

PLUG AND PLAY TECHNOLOGIES HELP PIECE TOGETHER GAS TO LIQUID CONVERSION PUZZLE



IMPACT

This research identifies the technical and economic opportunities for emerging GTL technologies opening the door for smaller plants to be able to increase the value of natural gas resources.

FOCUS AREA

Adding value to our energy resources

TARGET



An Alberta project team set out to solve the puzzle of identifying the best technology combinations needed to convert gas to liquids (GTL). The team is just waiting for the right market environment for industry to pull the trigger on a pilot project to further prove the technology.

Converting natural gas into higher value products such as diesel, diluent and lubricants involves a variety of technologies that have to fit and work together. A study completed in 2015, with a final report drafted in 2016, quantifies a variety of different combinations that show economic potential.

"[Alberta Innovates (AI)] brought in a horse race of technology providers and an engineering firm to help integrate that technology into the process. We were able to see capital and operating costs and revenues of various options in an Alberta-specific scenario to see what value it could create," said Neil Camarta, President and CEO, Field Upgrading.

The total project has seen an investment by AI of just under \$400,000 and additional support

from project partners EDT Energy, Suncor Energy, ConocoPhillips, Field Upgrading, and Hallmark Financial Solutions. The goal is to increase Alberta's capacity to develop, adapt and commercialize technologies that can add value to the province's natural and renewable resources.

Currently, proven commercial technologies are expensive and economic only at large capacities with high oil/gas ratios. But new technology combinations are showing signs smaller plant operations may become economically viable. These applications range from stand-alone gas-to-liquids facilities to integrated operations where heat and utilities can be shared for efficient production of multiple end products.



Hatch Engineering did a screening analysis of emerging technologies and looked at a number of different combinations not currently commercially ready. This included evaluation and selection of sites, technologies, design and cost, along with economic feasibility studies. The work has shown positive economic indications in two areas, including potential integration with Steam Assisted Gravity Drainage (SAGD) facilities. Internal rates of return ranged from 10-15 per cent; a positive indicator.

“Technologies for converting natural gas to liquids and other high value products are well on their way to being an attractive economic opportunity in Alberta,” said Nevin Fleming, Project Manager, Energy Systems, Alberta Innovates. “Heat and power integration synergies with other large scale industrial applications, like SAGD, may present additional benefits that need to be further explored and evaluated going forward. I think we’re going to see some exciting projects.”

CURRENTLY, PROVEN COMMERCIAL TECHNOLOGIES ARE EXPENSIVE AND ECONOMIC ONLY AT LARGE CAPACITIES WITH HIGH OIL/GAS RATIOS. BUT, NEW TECHNOLOGY COMBINATIONS ARE SHOWING SIGNS SMALLER PLANT OPERATIONS MAY BECOME ECONOMICALLY VIABLE.

These results provide valuable information and guidance for individual companies that are considering the next step — a site specific field demonstration. This will require a more stable market environment and a large capital investment.

“[Working with AI] It worked out exactly as we hoped. We were one of many companies, so we didn’t have to carry the whole cost, just a portion of it, and in the end we get the benefits of the results to make a sound business decision. Together we found the sweet spot of engineering and economics,” said Camarta. “It’s up to us to see if we can go hog-wild and invest some money into it and take it to the next level.”

NEW PROCESS TO TAKE STEAM OUT OF IN SITU BITUMEN RECOVERY

IMPACT

This could be one of the few in situ oil sands technology advancements in over 40 years - reducing GHG emissions, energy consumption and water use.

FOCUS AREA

Adding value to our energy resources

TARGETS



50%
sustainable oil
production



50%
reduction in
GHG intensity

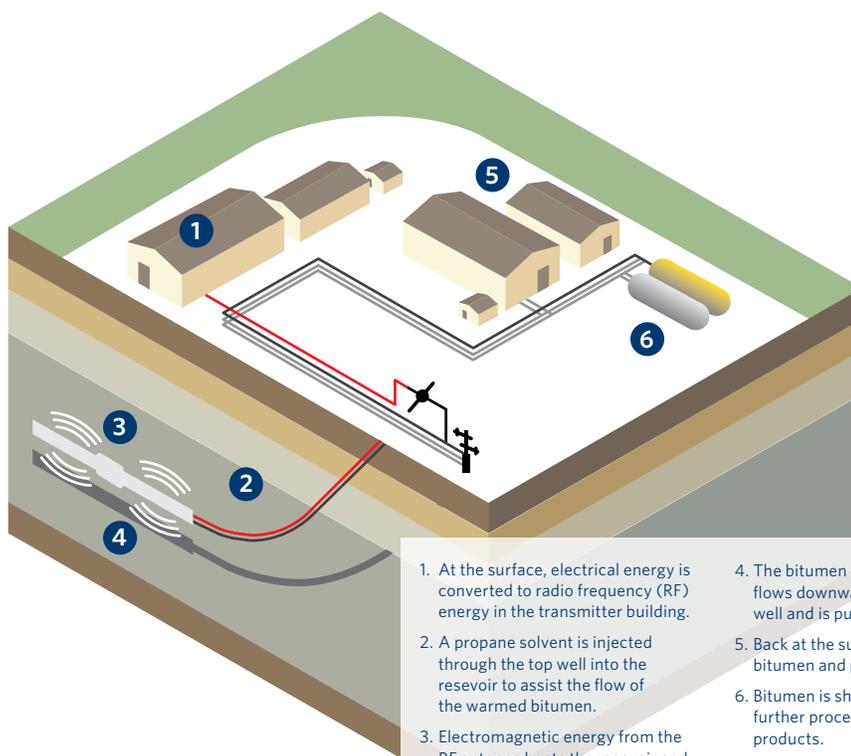
A novel technology, called ESEIEH, is taking the steam out of in situ bitumen recovery. The science works and the chemistry and the physics make sense, leaving professionals optimistic about this process that could advance in situ oil sands development in a low-carbon world.

The technology's acronym is pronounced "easy," and stands for Enhanced Solvent Extraction Incorporating Electromagnetic Heating. It is a new bitumen recovery process that replaces the need for water and steam by using electromagnetic heating in combination with solvent dilution. Sound easy? Not quite, yet the data shows early investments are paying off.

Through various stages of testing ongoing since 2012, the project team has been trying to prove the technology's potential to improve energy efficiency, reduce greenhouse gas emissions, eliminate water consumption and lower capital and operating costs. The project's target is 100 per cent less water, with a 60 per cent greenhouse gas intensity reduction which will contribute to Alberta Innovates (AI) goals of 50 per cent sustainable oil production and 50 per cent reduction in GHG intensity by 2030.

"We believe this technology is capable of making Alberta in situ bitumen recovery among the cleanest processes in the world, while doing so in an economically viable manner in an environment of lowered oil prices," said Margaret Byl, Executive Director, Energy Technologies, AI. "We are optimistic that the technology will be successful, and when it is, could be available to the whole industry."

"We need to be able to fast track technology in a collaborative and non-competitive approach with shared risks and rewards. This is a great example of that," said Bill MacFarlane, Senior Engineering Advisor, Research and Development, Nexen Energy. "It takes a fair bit of financial investment, tech capability and capacity, all supported by leadership to realize transformative, breakthrough technology like this."



1. At the surface, electrical energy is converted to radio frequency (RF) energy in the transmitter building.
2. A propane solvent is injected through the top well into the reservoir to assist the flow of the warmed bitumen.
3. Electromagnetic energy from the RF antenna heats the reservoir and mobilizes the bitumen, which mixes with the propane.
4. The bitumen and propane mixture flows downwards into the bottom well and is pumped to the surface.
5. Back at the surface, the mixture of bitumen and propane is separated.
6. Bitumen is shipped to refineries for further processing into petroleum products.

ESEIEH – pronounced “easy” is an in situ bitumen recovery method replacing the need for water by using electromagnetic heating in combination with solvent dilution.

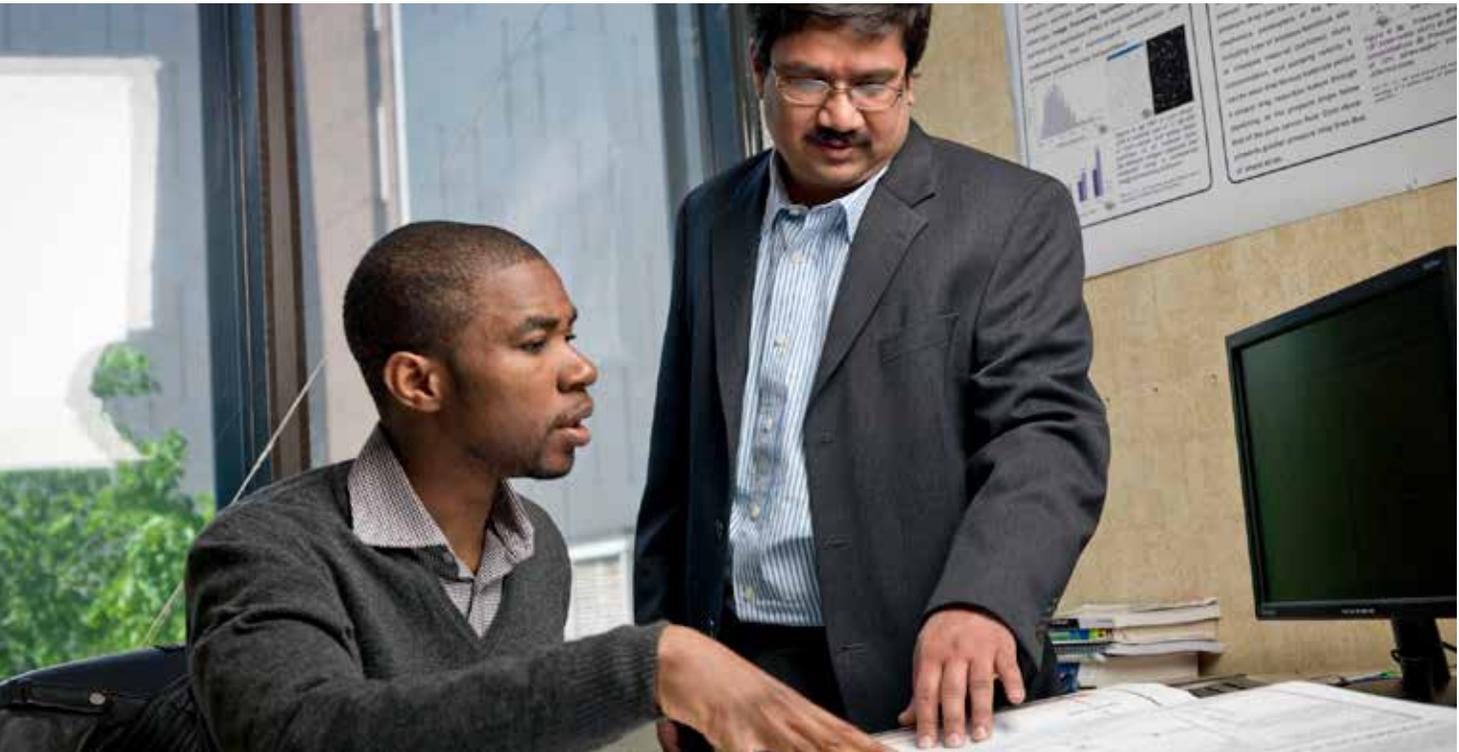
Suncor’s Dover site is playing host to Phase 2 of the project, a field pilot to prove the technology works in a horizontal well pair. Technology designers and developers are currently adjusting the engineering of the technology based on early-stage results and are set to re-deploy in early-2017. Results are expected later that year. A reservoir simulation tool has also been built for understanding how the process can be used across the oil sands and not just in the pilot location. Positive results will pave the way for a commercial scale demonstration facility.

“Piloting requires perseverance, courage and vision; there are always unexpected challenges but they must be worked through to achieve significant technology change and impact,” said Candice Paton, Senior Manager, Advanced Recovery, AI. “Despite these difficult times in the market, we are continuing to move forward with the testing to prove and commercialize this economically and environmentally promising technology.”

“WE BELIEVE THIS TECHNOLOGY IS CAPABLE OF MAKING ALBERTA IN SITU BITUMEN RECOVERY AMONG THE CLEANEST PROCESSES IN THE WORLD, WHILE DOING SO IN AN ECONOMICALLY VIABLE MANNER IN AN ENVIRONMENT OF LOWERED OIL PRICES,” SAID MARGARET BYL, EXECUTIVE DIRECTOR, ENERGY TECHNOLOGIES, AI.

The project is a collaboration of four industry petroleum and technology partners: Suncor Energy; Harris Corporation; Nexen Energy; and Devon Canada Corporation, with support by AI and funding in part from Alberta’s Climate Change and Emissions Management Corporation (CCEMC), now called Emissions Reduction Alberta (ERA).

MODELLING A CLEANER FUTURE



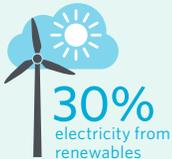
IMPACT

Industry and government can use these models to easily identify the opportunities for GHG mitigation that will help meet the Province's Climate Leadership goals.

FOCUS AREA

Climate Leadership

TARGETS



In its Climate Leadership Plan, the Government of Alberta made a commitment to reduce methane emissions from oil and gas operations by 45 per cent by 2025 and phase out greenhouse gas (GHG) emissions from coal-generated electricity by 2030. Alberta Innovates (AI) has a mandate to help the Province achieve these goals.

For the past decade, AI has been working with the University of Alberta on projects that identify the best opportunities for GHG emissions mitigation through energy efficiency and renewable energy initiatives. Dr. Amit Kumar, Professor of Mechanical Engineering, has developed and applies Alberta-specific energy systems models to estimate and compare scenarios for enhanced energy efficiencies. These models allow public and industry to make optimal decisions on the best return on investments when it comes to GHG reductions.

Dr. Kumar has just completed four new models that identify pathways to help the province meet its Climate Leadership goals:

- » Understanding the greenhouse gas mitigation potential through energy efficiency improvement in Alberta's chemical and pulp and paper sectors
- » Development of techno-economic models for estimating the cost of hydrogen production from hydro power for Alberta's oil sands and chemical industry
- » The techno-economic and life cycle assessments of biomass co-firing options in Alberta
- » Development of engineering based models to assess the cost and GHG footprint to supply Alberta's natural gas in the form of liquid natural gas to the Asia-Pacific region.

Dr. Kumar and his team have run hundreds of demand scenarios in these models. The key, he says, is to complete more than 250 scenarios, analyze their results and make them publicly available.

“Running many scenarios gives us lots of results for decision making. The models allow us to simplify very complex information about various energy systems. The results help us to understand GHG mitigation potential through to 2030 and 2050 as well as the associated cost potential,” he explains. “We take information from various sources and create models that provide relevant information.

“Our work can be used by decision makers in industry and government,” adds Dr. Kumar.

“For example, my understanding is that the Government of Alberta has used these modelling results to develop policies for GHG mitigation. The work is relevant for both Alberta and Canada — for both climate leadership and economic diversification.”

Suncor has also taken advantage of the models. “We have used Dr. Kumar’s models for greenhouse gas life cycle analysis to inform us on technology strategy on low carbon opportunities and options,” says Prit Kotecha, Manager, Water Strategy and Solutions at Suncor Energy. “Dr. Kumar’s life cycle analysis as part of an overall energy systems analysis, is unique and valuable.”

The current modelling work is part of the AI supported NSERC Industrial Chair in Energy and Environmental Systems Engineering.

“Alberta Innovates has always been an important partner,” says Kumar. “The work we do at the University aligns with AI’s focus on developing renewable energy and their mandate to help mitigate GHG emissions.”

The results for this work could determine which future planning options could have the most return on investment when it comes to GHG reductions. It also has potential for feeding into the government’s policy decisions in this area.

Four models for GHG Mitigation

GHG MITIGATION IN ALBERTA’S CHEMICAL AND PULP AND PAPER SECTORS

These models can be used to understanding the GHG mitigation potential through energy efficiency improvement in Alberta’s chemical sector. Using the Long-range Energy Alternative Planning systems model (LEAP), these assessments show potential of GHG emissions and the associated costs for each of the energy efficiency improvement scenarios. This work is a part of larger research initiative that estimates the potential of GHG mitigation through improvement of energy efficiency in Alberta’s energy

demand sectors including residential, commercial, transportation, mining, agriculture and pulp and paper sectors that were done previously.

HYDRO POWER HYDROGEN MODELLING

Renewable hydrogen from hydro power can be potentially used in bitumen upgrading, therefore mitigating significant GHG emissions in Alberta’s oil sands industry. The development of techno-economic models for estimating the cost of hydrogen production from hydro power is aimed at assessing renewable sources of producing hydrogen.

This work is a part of a larger initiative to assess the techno-economic viability of large scale hydrogen production from alternative sources.

BIO-MASS CO-FIRING MODELS

This study considered the techno-economic and life cycle assessments of biomass co-firing options in fossil-fuel power plants (e.g., natural gas and coal). This work involved the development of engineering based models to calculate the cost and GHG footprint of the various biomass co-firing levels in Alberta and the associated GHG abatement costs. The results of this study are useful

for the power industry and the government in making investment decisions as Alberta phases out the use of coal fired electricity.

OPPORTUNITIES FOR NATURAL GAS EXPORTS TO ASIA

This engineering based model can be used to assess the cost and GHG footprint to supply Alberta’s natural gas in the form of liquefied natural gas (LNG) to Asia Pacific. The aim is to diversify Alberta’s export market and work towards diversification of Alberta’s economy.

ALBERTA GIVES GEOTHERMAL ANOTHER LOOK



IMPACT

This study helps provide tools for municipalities and industry to develop clean energy options for specific regions in Alberta. This is a step toward helping Alberta meet its target of having 30 per cent of electricity come from renewable energy sources.

FOCUS

Climate Leadership

TARGETS



Using the earth's heat — otherwise known as geothermal energy — to generate heat and power is not a new concept. Geothermal energy has been embraced as a viable resource to produce renewable energy in other parts of the world, however, the sector is young in Alberta and has yet to gain traction.

Recognizing the need to really understand the potential of geothermal energy, Alberta Innovates (AI) teamed up with Dr. Jonathan Banks, at the University of Alberta and five municipalities to identify what it might take to put geothermal energy on the map. The project's focus was to analyze more than 10 geothermal reservoirs located close to these five municipalities. The reservoirs were studied for their potential to deploy heat and power to their neighboring communities. The goal of the study is to provide municipalities with the information they need to develop a geothermal heat or power initiative in their area.

"Geothermal energy has become a hot topic of discussion because of the Government's focus on renewable energy," says Maureen Kolla, Manager of Renewable Energy for AI. "This project helps us understand the opportunity for

geothermal energy production in the province. What we're learning is that there is a niche opportunity for geothermal heat or power. Geothermal energy could be a renewable energy source contributing to help Alberta meet its target of having 30 per cent renewable electricity."

Banks believes many of the pieces to bring geothermal online are already in place.

"We feel Alberta already has the technology resources," says Banks. "We know from our historical research there is geothermal energy available in Alberta. Drilling has become cheaper and more effective. We've been able to target smaller reservoirs with greater accuracy, and there is an increased political push to create better low carbon energy technologies. It is just a matter of putting the pieces together and then applying the technology."



HEAT FROM THE EARTH'S CRUST IS USED IN A GEOTHERMAL POWER PLANT TO DRIVE A TURBINE, WHICH CREATES ELECTRICITY. GEOTHERMAL HEAT CAN ALSO BE USED IN A VARIETY OF HEATING APPLICATIONS, SUCH AS RADIANT HOME HEATING OR HEATING FOR COMMERCIAL GREENHOUSES.

Alberta has good overall historical data of geothermal potential. There are several regional scale geothermal gradient maps for Alberta that can be found in the Geological Atlas of the Western Canada Sedimentary Basin. This is an area where AI has already done some work.

"AI, CanGEA and Suncor previously worked on a Geothermal Favorability Map that examined temperature and depth profiles showing the temperatures at different depths, plotted on a grid," explains Kolla. "All this data gives us a high level sense of what the regional potential for geothermal

is. What this new project has done, is put this data under the microscope to look at specific reservoirs close to municipalities and determine which reservoirs could provide geothermal energy to the communities."

Specifically, Banks is looking at the amount of thermal energy (heat) available in these specific reservoirs. Using that data he determines how much thermal energy is in the reservoir and then calculates how much recoverable heat and power that reservoir could produce. Banks says that by doing this he can quantify the potential rather than just look at a whole region and infer whether it has geothermal potential or it doesn't.

"Bridging the gap between academic studies and industry needs requires quantifiable, actionable, information. We think this study delivers that," says Banks. "Within these 10 reservoirs we've calculated there are between seven and fourteen hundred megawatts of power that could be accessed with existing technology."

While Banks acknowledges there are legislative and commercial challenges to overcome before geothermal is widely deployed in Alberta, he says there is enough energy to supply heat and electricity to a large portion of these municipalities.

"One megawatt is enough power for approximately eight hundred single family homes," Banks explains. "For a city about the size of Hinton, Alberta, with a population of about 10,000 people, they would require about 10 megawatts of power for residential use. The potential is there."

To further this project, AI and the University of Alberta co-hosted a workshop with geothermal stakeholders. Over 100 stakeholders came

The term geothermal energy is related to the thermal energy of Earth's interior. The deeper we go toward the earth's centre the greater the intensity of this thermal energy. On average, in Alberta, the temperature increases 30 degrees Celsius each kilometre closer to the earth's core.

Geothermal can be an attractive energy source because of its base-load power capability. While sun and wind power are intermittent, geothermal heat is constant and can even be turned up or down depending on demand.

Based on the geological and technical information compiled, there are 10 reservoirs within the five participating municipalities that have potential for geothermal heat or power development. The five participating municipalities are: City of Grand Prairie, County of Grand Prairie, Town of Hinton, Municipal District of Greenview and Tri-Council of Clearwater County, Village of Caroline and Town of Rocky Mountain House.



together to discuss geothermal heat and power potential, electricity and regulatory barriers and identify potential partnerships that could help move geothermal forward in the province.

“It is too early to say what the impact is on Alberta or the industry, however, there is definite interest in this area of study,” says Kolla. “The geothermal industry in Alberta is growing and our collaboration with Dr. Banks and the five municipalities will help to inform stakeholders of the potential resources available and where the greatest opportunities for development are.”

Sean Collins, President of Terrapin Geothermics was one of the participants at the Geothermal Workshop. Terrapin recently started a geothermal project with AI and Dr. David Nobes of the University of Alberta to develop a low-temperature heat engine that could be used to repurpose existing oil and gas wells to generate electricity from low temperature geothermal resources.

“Alberta’s geothermal industry is on the cusp of explosive growth,” says Collins, “The Deep Dive Geothermal Study conducted by Dr. Banks and AI is a crucial resource

WE KNOW FROM OUR HISTORICAL RESEARCH THERE IS GEOTHERMAL ENERGY AVAILABLE IN ALBERTA. DRILLING HAS BECOME CHEAPER AND MORE EFFECTIVE. WE’VE BEEN ABLE TO TARGET SMALLER RESERVOIRS WITH GREATER ACCURACY, AND THERE IS AN INCREASED POLITICAL PUSH TO CREATE BETTER LOW CARBON ENERGY TECHNOLOGIES.

to unlocking this new industry in Alberta. Without strong, foundational research into the ideal locations and methods of developing Alberta’s geothermal industry, we’re walking in the dark and likely to stumble.”

The second phase of Banks’ study is now underway. Phase 2 will provide a techno-economic assessment related to developing each of the 10 reservoirs. Together with Phase 1, the results will provide an understanding of the overall development potential of these reservoirs, leading to the development of geothermal initiatives in Alberta.

ADAPTED FUEL CELL TECHNOLOGY SHOWS PROMISE TO INCREASE ENERGY EFFICIENCY AND LOWER CARBON CAPTURE COSTS

IMPACT

The use of MCFC's for carbon capture has the potential to significantly reduce GHG emissions in existing power plants or oil sands facilities at a cost that is economically feasible.

FOCUS AREA

Climate Leadership

TARGET



Technology adaptation happens when you can take technology designed for one specific purpose, and adjust it for another use or benefit. Adaptation can save years of research time and hundreds of thousands of dollars.

Traditionally, fuel cells have been used in power generation plants to convert fuel into heat and electricity. Through new research supported by Alberta Innovates (AI), we have discovered the technology could also be adapted to capture CO₂ from the exhaust streams of natural gas fired power plants or oil sands facilities. This adaptation could lead to a promising new technology to help reduce greenhouse gas (GHG) emissions from energy production in the province.

Two feasibility studies have found that integrated with steam boiler or process heaters, the Molten Carbonate Fuel Cell (MCFC) process can be adapted for existing power plants to capture and compress carbon dioxide at much lower costs than competing commercial technologies. What's making MCFC such an attractive option so far is its ability to capture CO₂ and generate power at the same time. The power can be used to run on site operations or connect back to the grid as an additional source of revenue.

"Carbon capture and utilization has the potential to have significant impact on lowering greenhouse gas emissions that have proven otherwise difficult to reduce," said Candice Paton, Senior Manager, Advanced Recovery, AI. "Technologies are available but the cost needs to be reduced and feasibility in Alberta's industry and economic climate needs to be proven."

AI is now building on the promising preliminary results and is leading a project to illustrate the

opportunities of installing a megawatt-scale system at oil sands facilities. This project has the support of industry partners, who are monitoring the project for results that could be used at future sites. Based on the study outcomes, a decision will be made to move ahead with a pre-commercial pilot installation. Project partners are hoping to see carbon recovery between 70 and 90 per cent with generation of up to 1.4 megawatts of energy.

"One company cannot do this by themselves. Alberta Innovates' role has been so helpful in bringing together different opinions with busy schedules and varying resources. These collaborative approaches are what will help us get to the solution," said Anamika Mukherjee, Air and Energy Efficiency Specialist, Cenovus Energy. "If this project goes through to commercial stages, it will be one of the most successful examples of collaboration in the industry."

The development of low-cost carbon capture technologies has been an integral part of the portfolio developed by AI to reach its target of 50 per cent reduction in GHG emissions intensity by 2030.

"Carbon capture could support sustainable operation of our existing industries," said Paton. "What's great is that these technologies are not in the lab anymore, they are not at the beginning stages, but they are in the field or will be in the field very soon. Within the next five years, we could see some of these being commercial, having a direct effect on meeting our Climate Leadership goals."



RIVER BASIN BENEFITS FROM COLLECTIVE APPROACH TO WATER MANAGEMENT

IMPACT

Being able to bring together a vast group of stakeholders has led to a comprehensive plan to ensure basins are healthy for many years to come.

FOCUS AREA

Adaptation

TARGET



A collaborative approach to water management has led to a new roadmap for how Alberta can sustainably manage the complexities of its water supply and demand for future generations.

Experts from throughout the South Saskatchewan River Basin have developed a fact-based, operational model to address stresses facing the watershed: a growing economy; expanding population; shifting climate patterns; and the increased impact these factors have on the health of the watershed.

The newly developed South Saskatchewan River Operational Model (SSROM) project was supported by \$1.8 million in funding from Alberta Innovates (AI), \$1.6 million from the Climate Change and Emissions Management Corporation (now ERA), and contributions from participants including the Government of Alberta. Alberta WaterSMART has led this integrated approach since 2008 involving multiple sectors: recreation; agriculture; resource industries; municipalities; government and NGO's.

“People came to the table because they recognized an opportunity to address these challenges by looking at the river system as a whole to better understand its users and their various perspectives,” said Megan Van Ham, Director of Programs, Alberta WaterSMART. “They had a shared interest, they were trusting and transparent, and once you have that you can objectively assess ways to change and improve the system.”

Published in January of 2016, the Adaption Roadmap for Sustainable Water Management in the South Saskatchewan River Basin Project Final Report outlines strategies for the overall basin including the Bow, Oldman, Red Deer, and South Saskatchewan rivers. The roadmap includes the need for a long-term management agreement with TransAlta for the Bow River upstream of Calgary, optimizing

The following organizations are part of the SSROM and sub-basin working groups:

Alberta Agriculture and Forestry	City of Lethbridge	Special Areas Board
Alberta Environment and Parks	City of Medicine Hat	St. Mary River Irrigation District
Alberta Environmental Monitoring, Evaluation and Reporting Agency	City of Red Deer	Suncor
Alberta Irrigation Projects Association	Ducks Unlimited Canada	Taber Irrigation District
Alberta Wilderness Association	Eastern Irrigation District	TransAlta Utilities
ALCES	Highwood Management Plan – Public Advisory Committee	Trout Unlimited
Bow River Basin Council	Prairie Adaptation Research Collaborative	University of Lethbridge
Bow River Irrigation District	Red Deer River Watershed Alliance	Western Irrigation District
City of Calgary	Shell Canada	West Fraser Timber
	South East Alberta Watershed Alliance	Alberta WaterSMART
		HydroLogics Inc.



use of existing irrigation reservoirs, developing shortage sharing frameworks and restricting development on floodplains. The final report was presented to the Government of Alberta; some recommendations are already in progress.

“We were successfully able to connect ideas, technology, and best practices with the people that need to solve problems,” said Brett Purdy, Executive Director, Water and Environmental Management, AI. “Putting these models in place, collecting the data together, allows us all to understand opportunities and impacts in an integrated and comprehensive way.”

The SSROM allows stakeholders to test scenarios to see where one need is met, how it affects others. While most of the work revolved around drought mitigation, the 2013 Alberta flood challenged the working groups to also determine how to manage too much water. For instance, if reservoirs are lowered, how will that affect hydropower generation and water storage for agriculture production?

PUBLISHED IN JANUARY OF 2016, THE ADAPTION ROADMAP FOR SUSTAINABLE WATER MANAGEMENT IN THE SOUTH SASKATCHEWAN RIVER BASIN PROJECT FINAL REPORT OUTLINES STRATEGIES FOR THE OVERALL BASIN INCLUDING THE BOW, OLDMAN, RED DEER, AND SOUTH SASKATCHEWAN RIVERS.

The process was deemed so much of a success that it will be piloted to address issues of water management on other river systems, including the Athabasca.

“We want our river systems to be healthy and wild, but we also want to support and encourage economic and social growth. To balance those needs you need resident expertise collectively identifying promising opportunities,” said Van Ham. “Alberta Innovates has been incredible in supporting this project, and others that have led up to it, and that investment is truly paying off with high functioning working groups supported by facts and models that can be put to any challenge.”

TAILINGS TECHNOLOGY ONE STEP CLOSER TO COMMERCIALIZATION



There are currently over 1 billion m³ of Mature Fine Tailings (MFT) contained in approximately 10 tailings ponds of varying sizes and volumes

IMPACT

If proven at commercial scale, this technology has the potential to treat about 200 million m³ of MFT and significantly progress the 2030 target of a 100 million m³ reduction of legacy mature fine tailings over and above government directives.

FOCUS AREA

Adaptation

TARGET



Alberta Innovates (AI) has been working on tailings treatment technologies that will allow more effective reuse and recycle of oil sands process-affected water.

This year, one of our partners, EKS Solutions, reached an important scale-up benchmark. Initial testing of their EKS technology (reported in the 2014-15 Report on Outcomes) was positive, but the question remained: can it work at a large scale?

The EKS technology applies electricity in tailings ponds to cause water to be released and the remaining clay particles to consolidate and solidify. This process allows oil sands mining companies to remove and recycle the water without the use of chemicals. This technology can dewater fine tailings while in the tailings ponds (in situ) avoiding the costs and energy required with repeated transportation and handling. When the tailings are dewatered, a stable landform is produced that is ready for final reclamation within a year or two compared to what could take 50 years or more with current technologies. The EKS technology could become commercially viable within the next five years.

Early stage testing last year, using a 25m³ tailings tank showed positive results and the potential

for both technological and economic feasibility.

"We often see technologies fail during scale-up," says Rick Nelson, Senior Director, Tailings Management at AI. "There are many variables that can't be replicated in labs and at smaller test sizes. When you take a technology to a pilot or demonstration phase that's when the critical technology assessment begins."

Working with another AI subsidiary, C-FER Technologies, EKS recently passed an important milestone. Using a large 130m³ test tank the earlier results were replicated, suggesting the technology is scalable.

"We can provide a cost effective technology and offer a solids content that is as high or perhaps higher than any other technology out there," says EKS president, Jim Micak. "This is based on our testing so far. Now we're looking forward to seeing how the technology performs at a commercial scale."

The next phase of this project is a field demonstration, which AI will be collaborating on. The field pilot will be located on an oil sands mining lease in 2017.



PEAT BOGS IN NORTHERN ALBERTA REVEAL HEAVY METAL INSIGHTS

IMPACT

The data from the ultra clean lab will facilitate a more accurate conversation about the impacts of the oil sands industry on the environment and help government identify and mitigate risks to public health.

FOCUS AREA

Adaptation

TARGET



New peat moss studies are challenging contemporary thinking on heavy metal levels upstream of Fort McMurray and downstream from industry. We sat down to speak to Dr. William Shotyk to talk about his latest research findings.

Dr. Shotyk has been studying lead in the atmosphere for over 30 years. Through peat bogs in Switzerland's Jura Mountains and ice cores in the Canadian arctic, the renowned geochemist has archived deposits as far back as 15,000 years. Over the past five years, the University of Alberta professor and Bock Chair of Agriculture and the Environment for the Department of Renewable Resources, has focused his research intensively on Northern Alberta through the support of \$2.1 million in funding from Alberta Innovates. He is currently publishing his research in peer reviewed journals, speaking at conferences, and sharing his findings through mainstream media.

Can you explain what you discovered during this five-year research project?

Atmospheric lead contamination has been in decline for decades; it reached its peak 40 years ago. Today we are at a point where we are more or less back to natural levels. If you look at the moss collected around oil sands open pit mines, it has a ratio of lead to thorium which matches values seen in Swiss peat bogs between 5,000 and 8,000 years ago. If there was any lead coming from that industry, it would be preserved in these peat cores, it's just not there. This lack of contamination is testimony to decades of successful international efforts to reduce emissions of this toxic metal in the atmosphere. It's a really good news story; perhaps it caught a lot of people off guard.



MOSS TELLS US WHAT'S LANDING ON THE SURFACE TODAY. IF WE DIG DOWN THROUGH THE BOG, COLLECT CORE SAMPLES, FREEZE THEM AND PRECISELY SLICE THEM, WE CAN RECONSTRUCT WHAT AIR WAS LIKE IN THE PAST DECADES, CENTURIES, AND MILLENNIA.

Why peat bogs?

Moss is a cool plant. It has no roots and survives on inputs from the atmosphere. By measuring the contaminants in moss we know what's in the atmosphere. Because bogs are waterlogged, organic matter accumulates faster than it breaks down. Moss tells us what's landing on the surface today. If we dig down through the bog, collect core samples, freeze them and precisely slice them, we can reconstruct what air was like in the past decades, centuries, and millennia.

Where did you conduct your research?

It has been suggested that industrial development of the oil sands is a significant source of lead in the environment. We

collected core samples from five bogs within 70-kilometres of open pit bitumen mines and upgraders, with the nearest just 11-kilometres away. We work out of the SWAMP (soil, water, air, manure and plants) Lab [at the University of Alberta]. It's a \$5 million ultra-clean research facility for studying trace metals in soil, water, air, manure, and plants. It's metal-free, and made out of plastic. We can measure lead down to levels lower than almost any other lab.

You also studied the nearby Athabasca River, tell us about that work.

We've done two intensive 15-day trips on the Athabasca River. We were out from early in the morning to late in the evening with ultra clean bottles, filters and syringes and sampled upstream of Fort McMurray and downstream from industry, in the middle of the river in front of tailings ponds and upgraders, looking for potentially toxic metals. All of the heavy metals we recorded are present at extremely low levels; no more downstream, below the industrial activity, compared to upstream.



What's happened to shift us toward a downward trend?

The introduction of unleaded gasoline — I know that quite well as I still have my old 1976 GMC Sierra pickup truck. On the sun visor it says the “vehicle is not equipped with a catalytic converter and can use leaded or unleaded fuel.” Lead contamination has been in the decline since we started using unleaded fuel. The health of hundreds of millions people worldwide was affected by leaded gasoline. This decline is a cause for celebration.

What other findings did the research produce?

A companion paper is currently being reviewed and it shows all the other heavy metals are in decline too. More good news. These metals in the air have been in decline for decades: silver; cadmium; antimony; and thallium. Because leaded gas contains lead, and none of the other stuff, there must be something else going on. Our guess is passage of the Clean Air Acts, in the U.S. and U.K., and similar legislation

elsewhere in the mid 1950's has caused an industrial behavior change that led to this decline.

What value did Alberta Innovates bring to the project?

They made this happen. I have never before been so well supported by a research funding organization; I've never had this much engagement. They've wanted to see us succeed from the beginning, so that level of support has been fantastic.

High concentrations of lead can have health effects such as: increased blood pressure and hypertension; decreased kidney function; anemia; neurological damage; and reproductive problems.

RESULTS ACHIEVED



POSITIONING FOR THE FUTURE

Technological innovation is critical to overcoming the market challenges, managing the risks and growing Alberta's and Canada's leadership in energy, climate change and environment. Significant dollars are being invested annually by industry and government on environmental monitoring, research, development, and technology deployment mostly associated with current technologies. There is a need, however, to accelerate the pace of development, and especially focus efforts on new transformational technologies.

As the lead agency for energy and environmental innovation in Alberta, AI develops the right partnerships to deliver on its mandate. Over 90 per cent of Alberta Innovates Clean Energy projects (including those in universities) have industry

partners. Within Clean Energy, a funding leverage of at least 2.9 to 1 is achieved (e.g., AI \$87 million investment has led to \$340 million in project funding). The Corporation has a proven history of bringing together decision makers from government and industry, as well as research and technology organizations (including post-secondary institutions) to identify and address technology and innovation gaps that can manage external risks and 'change-the-game' for Alberta.

It is Alberta Innovates' role to be ahead of emerging issues and foresee market opportunities. The Corporation's unique business model allows us to partner to develop solutions for the biggest challenges and opportunities facing Alberta's clean energy sector.

PERFORMANCE MEASURES – ACHIEVEMENT OF LONG-TERM TARGETS

AI aims to strengthen Alberta’s research and innovation capacity. Our core business is to position Alberta to achieve superior environmental performance while supporting the growth and diversification of the provincial economy.

Within Clean Energy, the ProGrid™ method is used for measuring achievement of its long term targets. This methodology provides a way to measure assets that do not necessarily show up on a balance sheet—the Corporation’s strategic approach, the effectiveness of staff and management systems, effectiveness of partnerships, the Corporation’s ability to influence directions, and the outcomes relative to the defined targets. In 2015-16, Alberta Innovates, Clean Energy, fine-tuned its major and minor areas of focus based on the shift in challenges facing the province. Results across these areas continued to be solid in 2015-16:

» Energy Technologies held its position for the past several years. The small changes each year are due to factors such as the declining ability of companies in the energy sector to fund technology development due to the low commodity price environment and severe cash constraints. This has resulted in challenges moving investments to commercialization, and

reaching Energy Technologies’ 2030 goals. With low oil prices over the last year, and continued low forecasts, companies and government will be challenged to find sufficient funds for the significant investments required to advance technology.

- » Renewables and Emerging Technologies strengthened its management capacity and its response to enable renewable energy through energy storage technologies. Its waste-to-value added program made the most impact in 2015-16. The change in government and the increased emphasis on renewable energy has resulted in additional financial resources for this group.
- » Water and Environmental Management further established AI as a leading agency in developing knowledge and innovation to support Alberta’s Water for Life strategy. Investments in Integrated Land Management and Tailings Management have led to advances in fundamental understanding, monitoring methods, and reclamation technologies, all of which contributed to informing policy development. In GHG management, novel technologies are advancing to the pilot stage to reduce carbon capture costs by 50 per cent.

Level O Evaluation (evaluator average):

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17 to 2018-19 targets	2019-20 target	2029-30 target
R- Value¹	38.09	46.26	47.59	56.86	57.63	61.12	62 ²	67.00	100.00
X	3.03	4.63	4.07	5.33	5.50	5.68		6.70	10
Y	4.45	4.62	5.55	6.07	6.04	6.60		6.70	10

¹ The R value is derived from the input of senior management in assessing several criteria that affect Clean Energy’s performance.

² The Government’s 2016-17 funding reduction to AI and continued low oil prices will significantly impact the pilot and field demonstrations required to advance the score.

RESULTS ACHIEVED

ACCELERATING COMMERCIALIZATION - TECHNOLOGY READINESS LEVELS

Goal Statement: Invest in a portfolio of projects along the Technology Readiness Levels (TRL) scale.

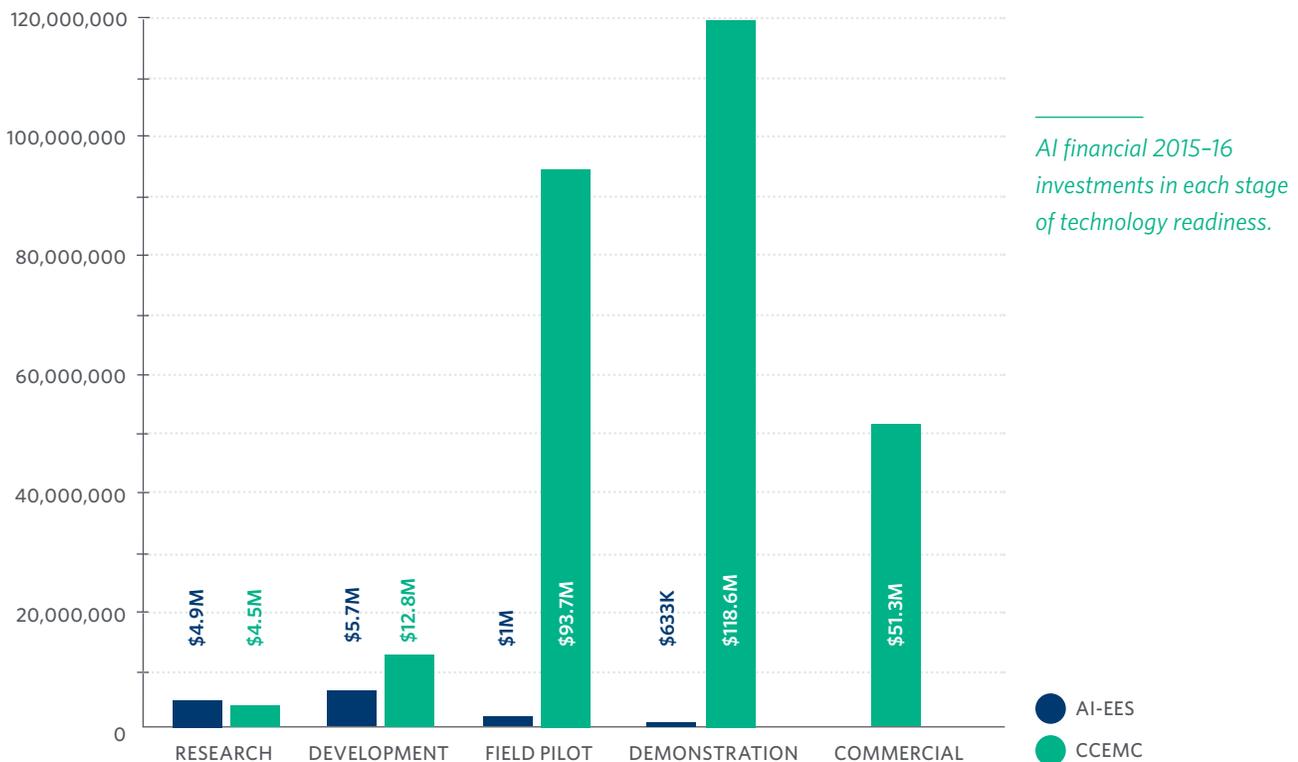
Technology readiness levels are used to show that Alberta Innovates (AI) is moving technologies towards commercial implementation. In terms of dollar value, in 2015-16, AI invested more in the Development stage than last year, while the number of projects was consistent. In all other stages, AI invested less in 2015-16 than in prior years. This is partly due to a decrease in overall research investments in 2015-16. In the low commodity price environment, our key industry partners—namely the oil sands industry—have severe cash constraints and a limited ability to fund technology development and demonstration.

Significant investments are required for field pilots and demonstration projects, especially in Energy Technologies. AI continues to partner with CCEMC (now Emissions Reduction

Alberta (ERA)) to ensure that the funds for pilots are available and moving projects toward commercialization.

As of March 31, 2016, the 81 active projects in the AI portfolio were analyzed and placed on the simplified TRL scale of research, development, pilot, demonstration, and commercialization. AI, as the project manager for projects of the ERA, also tracks the 73 active projects in the ERA portfolio.

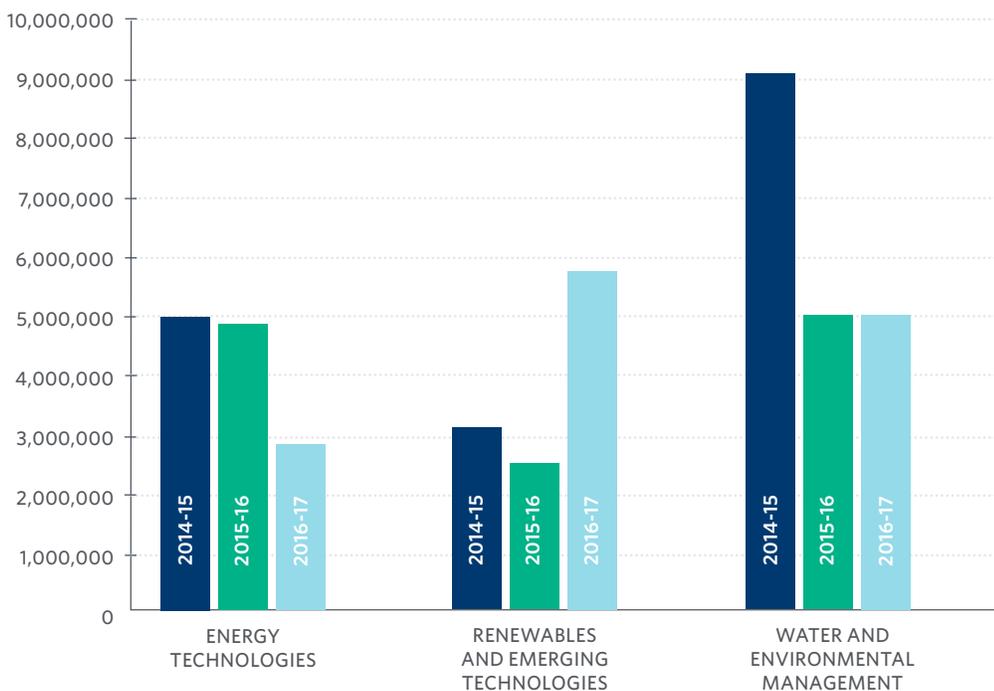
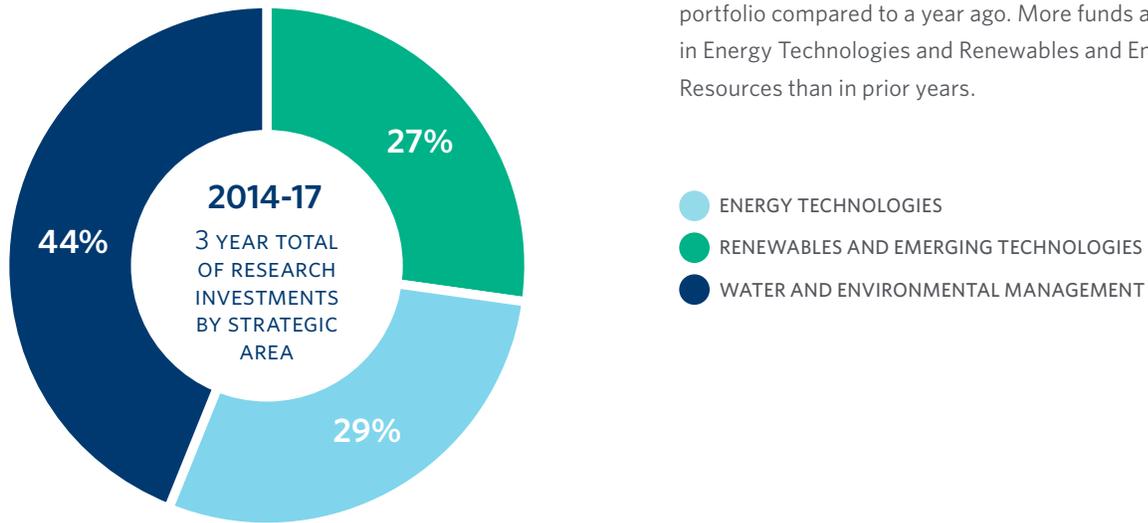
The chart shows a balanced portfolio with AI projects mostly at the earlier stages of development and ERA projects toward the commercialization end. Some projects originally developed with AI and that fit the ERA mandate, have transitioned to being funded by ERA to see them through the more expensive stages of pilot and demonstration.



MAINTAINING A BALANCED PORTFOLIO

Goal Statement: Maintain a balanced portfolio of projects in three strategic areas.

Alberta Innovates (AI) has maintained the balance in its portfolio compared to a year ago. More funds are spent in Energy Technologies and Renewables and Emerging Resources than in prior years.



Investments in Energy Technologies will be reduced in future years, in part due to a reduced overall budget and to reflect government priorities in renewable energy and environmental issues.

KNOWLEDGE TRANSFER



Knowledge management practices ensure project outcomes achieve the maximum uptake and translate into changes in industry practice. In 2015-16, Alberta Innovates (AI) realized knowledge transfer results that influenced policy and regulatory framework development and decisions.

The Technology Informing Policy committee, hosted by Alberta Innovates, has been an effective mechanism for knowledge transfer within the Government of Alberta. This collaboration with sector-related ministries has shared in over 56 project outcomes that either informed policy development or addressed barriers required for technology deployment.

Sharing outcomes also takes place through outreach at conferences, trade shows, and other events. Some of the significant activities are listed here:

- » Government of Alberta Learning Session, for government staff, hosted annually by AI
- » Alberta Innovates annual Technology Talks, shares updates and inspires collaboration with industry, government and academia
- » Water Innovation Program forum, held annually with thought leaders and stakeholders from around the province
- » Alberta Innovates hosted delegates at their trade show booths at Canadian Heavy Oil Conference, Global Petroleum Show GPS and World Heavy Oil Congress (WHOC)
- » Navigate 2016, a youth water summit organized by Inside Education
- » COSIA/AI co-hosted water conference in Calgary.

THOUGHT LEADERSHIP

2015–2016 STAFF PRESENTATIONS

In 2015–16, our staff continued its contribution to global thought leadership — as they were called upon to deliver more than 70 presentations and speeches on topics ranging from reducing GHG emissions in the oil sands to increasing the competitiveness of our energy resources to advancing environmental performance through our Water Innovation Program.

JOHN ZHOU

VP, Clean Energy

Implementing the AI-EES strategy, Government of Alberta Learning Session, Edmonton, *June 2015*

Carbon capture and storage technologies, an interview with Alberta Oil Magazine, Edmonton, *July 2015*

Cutting energy's footprint – toward a Canadian energy and environment strategy, panel member at the Conference Board of Canada, Ottawa, *September 2015*

Application of molten carbonate fuel cell for CO₂ capture in thermal in situ oil sands facilities, co-author published in the International Journal of Greenhouse Gas Control, Edmonton, *October 2015*

The properties and safe transportation of dilbit, AI-EES Technology Talks, Calgary, *October 2015*

Presentation on Alberta Innovates, Alberta Research and Innovation Authority (ARIA), Edmonton, *December 2015*

Presentation on Alberta Innovates, Energy Technology Community of Practice / Energy Technical Services meeting, Alberta Department of Energy, *December 2015*

Guest lecturer, University of Alberta's Department of Marketing, Business, Economics and Law, Edmonton, *January 2016*

Presentation on updates of innovation, Alberta Research and Innovation Authority (ARIA), Edmonton, *January 2016*

MARGARET BYL

Executive Director, Energy Technologies

Energy Technologies, AI-EES Technology Talks, Calgary, *October 2015*

Moving toward a more sustainable economy, Alberta-Quebec Climate Change Alliance, Calgary, *February 2016*

SURINDAR SINGH

Executive Director, Renewables and Emerging Technologies

Carbon capture and storage (CCS) initiatives in Alberta, Technology Transfer Workshop between the Carbon Capture and Storage and Geothermal Industries, CanGEA, Calgary, *May 2015*

GHG emissions reductions, AI-EES Technology Talks, Calgary, *October 2015*

Research and innovation in Alberta's energy and environment sectors, Presentation to the Mexican Energy Trade Mission, Edmonton, *November 2015*

Strategic priorities: Renewables and Emerging Technologies, Presentation at the "Building Collaborations" Workshop, CanmetENERGY, Devon, *February 2016*

BRETT PURDY

Executive Director, Water and Environment Management

Overview of the Biodiversity Chair, Government of Alberta Learning Session, Edmonton, *June 2015*

Founder Award recipient, EnviroAnalysis, Banff, *July 2015*

Investments in environment and water research, CREATE (Collaborative Research and Training Experience Program) Environmental Chemistry and Eco-toxicology, University of Alberta, Edmonton, *July 2015*

THOUGHT LEADERSHIP

2015–2016 STAFF PRESENTATIONS

BRETT PURDY CONTINUED

Water Innovation Program, Water Wisdom Speaker Series by JuneWarren-Nickle's Energy Group, Calgary, *October 2015*

Water Innovation Program, AI-EES Technology Talks, Calgary, *October 2015*

Water Innovation Program, NAIT student workshop, Edmonton, *November 2015*

Water Innovation Program, ARBRI Day 2015 Collaborative Research Conference, Edmonton, *November 2015*

Water Innovation Program, Lecture series, University of Calgary, *October 2015*

Water Innovation Program, Lecture series, University of Alberta, *November 2015*

Water Innovation Program, Watershed Planning Advisory Council (WPAC) Annual Forum, Leduc, *January 2016*

Water Innovation Program, Transboundary Water Secretariat in Alberta Environment and Parks, Edmonton, *February 2016*

Water Innovation Program, 2016 Western Canada Water Forum, Edmonton, *February 2016*

Reclamation and restoration ecology – Responsible land and water management practices for oil sands development, Oil Sands Mine and In Situ Water Workshop, Calgary, *March 2016*

Addressing Alberta's water challenges and opportunities – AI-EES Water Innovation Program, COSIA/AI-EES Water Conference, Calgary, *March 2016*

NEVIN FLEMING

Manager, Energy Systems

Energy Technologies – Gas to liquids update, Government of Alberta Learning Session, Edmonton, *June 2015*

Competitiveness of oil sands crudes in global markets, AI-EES Technology Talks, Calgary, *October 2015*

Master of Ceremonies, National Partial Upgrading Program (NPUP) workshop, Calgary, *January 2015*

SHUNLAN LIU

Director, Upgrading

Partial upgrading, Government of Alberta Learning Session, Edmonton, *June 2015*

Host and presenter, Alberta Biogas Workshop, Calgary, *October 2015*

Competitiveness of oil sands crudes in global markets, AI-EES Technology Talks, Calgary, *October 2015*

Where should Canada position itself along the oil value chain: bitumen, partial upgrading or refined petroleum products, CERI 2016 Oil and Gas Symposium, Calgary, *March 2016*

JON SWEETMAN

Senior Manager, Integrated Land Management

Water Innovation Program overview, Government of Alberta Learning Session, Edmonton, *June 2015*

DALLAS JOHNSON

Director, Integrated Land Management

Building a more competitive Alberta, Alberta Biodiversity Chair Meeting, Edmonton, *February 2016*

VICKI LIGHTBOWN

Senior Manager, GHG and Water Management

SAGD water and GHG, Government of Alberta Learning Session, Edmonton, *June 2015*

Application of molten carbonate fuel cell for CO₂ capture in thermal in situ oil sands facilities, co-author published in the International Journal of Greenhouse Gas Control, Edmonton, *October 2015*

Young women in energy, 2015 Young Women in Energy Gala, Calgary, *October 2015*

GHG and water management, Energy Technology – Community of Practice / Energy Technical Services, Edmonton, *December 2015*

DUKE DU PLESSIS

Senior Advisor, Energy Technologies

Award recipient - Edmonton's Advanced Energy Research Facility (AERF), Clean50 - Top 15 Projects for 2016, Edmonton, September 2015

Competitiveness Study, Canadian Heavy Oil Conference, Calgary, November 2015

Energy value chain and where technology can play a role, Calgary Economic Development, Calgary, November 2015

Competitiveness Study, 2015 BCN AI-Bio Conference, Edmonton, November 2015

Master of Ceremonies, National Partial Upgrading Program Workshop, Calgary, January 2016

Partial Upgrading of Western Canadian bitumen and heavy oil, CHOA technical lunch, Calgary, February 2016

MARK SUMMERS

Director, Renewable Energy

Clean power generation for Alberta, Government of Alberta Learning Session, Edmonton, June, 2015

CCEMC and ABMI: Partnering for biodiversity adaptation, The Impacts of Climate Change on Alberta's Biodiversity, Edmonton, June 2015

Alberta's efforts toward post-combustion capture, IEAGHG meeting, Regina SK, September 2015

CCEMC funding opportunities, SDTC Funding Workshop, Calgary, September 2015

Breakthroughs in carbon dioxide utilization technology, 5th Carbon Dioxide Utilization Summit on behalf of CCEMC, Germany, October 2015

Clean electricity for Alberta - Powering technology development, AI-EES Technology Talks, Calgary, October 2015

Energy storage - A chance for Alberta's power system, Canadian German Conference on Grid Integration of Renewable Energies, Calgary, November 2015

Reducing GHGs - Funding a way forward, BCIC/COSIA

Cleantech Energy Innovation Challenge, Vancouver, March 2016

CCECM-SDTC joint call for proposals - Innovation opportunities for Canada's SME community, GLOBE 2016 Conference, Vancouver, March 2016

MAUREEN KOLLA

Manager, Renewable Energy

AI-EES renewable energy, Canadian Heavy Oil Conference, Calgary, November 2015

Landfill Free Alberta, Government of Alberta Learning Session, Edmonton, June, 2015

Landfill Free Alberta, AI-EES Technology Talks, Calgary, October 2015

BABATUNDE (TUNDE) OLATEJU

Project Specialist, Technology Intelligence

Sustainable clean power, Sustainable Clean Power Generation Initiative meeting, Calgary, July 2015

Plasma gasification, Interview on CBC, Eye-Opener, Calgary, December 2015

Presenter, Alberta Biogas Workshop, Calgary, October 2015

EDDY ISAACS

Executive Advisor

Slugging It Out Environmental Panel, Canadian Heavy Oil Association (CHOA), Calgary, April 2015

Canada's energy agenda: Getting it right by the Economic Club of Canada, Panel discussion with the Economic Voice Series, in Partners with Senator Doug Black, Edmonton, April 2015

Keynote Presentation, 2015 Canada/Korea AKCSE annual conference, Kananaskis, July 2015

What comes after oil?, Public Roundtable at the Art Gallery of Alberta, Edmonton, September 2015

THOUGHT LEADERSHIP

2015–2016 STAFF PRESENTATIONS

EDDY ISAACS CONTINUED

Executive presentation, Energy Executive meeting at the Department of Energy, Edmonton, *October 2015*

Reducing GHG's in the oil sands, Interview with Bloomberg News, Edmonton, *November 2015*

Oil sands innovation, Interview with BNN, Toronto, ON, *November 2015*

Keynote presentation, BCIC/COSIA Cleantech Energy Innovation Challenge, Vancouver, BC, *November 2015*

Guest lecturer, World Engineering Conference and Convention (WECC 2015), Japan, *December 2015*

Key priorities, a Balanced Portfolio and 2050 Targets, Energy Innovation Workshop, Edmonton, *January 2016*

XIAOMEI LI

Senior Advisor, Bioenergy

Panel member, Alberta's Climate Change Panel – Agriculture, Forestry and Waste Technical Session, Edmonton, *September 2015*

Technology Intelligence: Identification of the best solid organic waste conversion technologies for Alberta, 65th Canadian Chemical Engineering Conference, Calgary, *October 2015*

ALEXANDER ZEHNDER

Senior Advisor, Water Management

Alberta's water challenges and opportunities, Wasser Berlin International GWP Forum, Germany, *March 2015*

How much water for what, where and for how much?, University of Alberta lecture series, Edmonton, *September 2015*

The global water challenges, York University lecture series, Toronto, ON, *September 2015*

OUR TEAM

Eddy Isaacs

CEO

John Zhou

Chief Technology Officer
(now VP Clean Energy)

WATER AND ENVIRONMENTAL MANAGEMENT

Brett Purdy

Acting Executive Director,
Water and Environmental
Management

Rick Nelson

Senior Director,
Oil Sands Tailings

Dallas Johnson

Director, Integrated Land
Management

Vicki Lightbown

Senior Manager, GHG
and Water Treatment

Alexander Zehnder

Scientific Director,
Water Resources

Dianne White

Program Officer,
Water Resources

ENERGY TECHNOLOGIES

Margaret Byl

Executive Director,
Energy Technologies

Shunlan Liu

Director, Upgrading

Kate Wilson

Director, Technology
Development

Candice Paton

Senior Manager,
Advanced Recovery

Nevin Fleming

Manager, Energy Systems

Eddy Isaacs

Executive Advisor (formerly
served as CEO of Energy and
Environment Solutions)

Duke du Plessis

Senior Advisor,
Energy Technologies

Linda Russell

Administrative Support

RENEWABLES AND EMERGING TECHNOLOGIES

Surindar Singh

Executive Director,
Renewables and
Emerging Technologies

Mark Summer

Director, Renewable Energy
(now Technical Director,
Emissions Reduction Alberta)

Maureen Kolla

Manager, Renewable Energy

Babatunde (Tunde) Olateju

Project Specialist,
Technology Intelligence

Xiaomei Li

Senior Advisor, Bioenergy

Lolita Ledesma

Administrative Support

KNOWLEDGE TRANSFER

Lisa Spinks

Senior Manager,
Technology Transfer and
Knowledge Management

Christine Stewart

Enterprise Content
Management Specialist

Hilary Stamper

Information Management

Traci Kwan

Project Information
Administrator

Janet Lilly

Records Clerk

OPERATIONS STAFF

Alice Barr

Senior Director, Strategic
Planning and Operations

Michelle Gurney

Communications Director

Bruce Marpole

Communications Advisor

Libuse Kuzel

Director, Human Resources

Joan Adams

Payroll and Benefits Specialist

Marta Bor

Administrative Support

Donna Kostuik

Executive Assistant

OUR BOARD

JUDY FAIRBURN

Board Chair

Ms. Fairburn holds a Master of Science degree in chemical engineering from the University of Calgary and a Master of Business Administration degree from the Richard Ivey School of Business at the University of Western Ontario. She has been named a Fellow of the Canadian Academy of Engineering and was honored for Canadian sustainable development leadership as a 2013 Clean 16 award winner.

In her current position as Executive Vice-President Business Innovation with Cenovus Energy, Ms. Fairburn is at the leading edge of collaborative innovation in Alberta's resource industry. She understands the challenges facing Alberta and how investment in technology and innovation across all sectors will provide greater economic diversity, environmental and social progress. This expertise, coupled with her network, governance experience and public policy understanding enables her to drive the innovation agenda forward, through collaboration with multiple stakeholders.

Ms. Fairburn's previous executive and senior leadership responsibilities include strategic planning, environment, portfolio management, corporate venture capital, refining, operations and technology development. She has worked with the Canadian government as a visiting executive in the Privy Council office. Ms. Fairburn was pivotal in the creation of Canada's Oil Sands Innovation Alliance (COSIA) and was its inaugural Chair. She is co-founder and Director of Evok Innovations – a unique partnership between cleantech entrepreneurs, Suncor and Cenovus to transform the Canadian oil and gas value chain by accelerating technology that addresses the most pressing environmental and economic challenges. She is also a Director with the Public Policy Forum and Sustainable Technology Development Canada and has been the Board Chair of Alberta Innovates Technology Futures.

DOUG GILPIN

Board Vice-Chair

Mr. Gilpin is a Fellow of the Institute of Chartered Accountants of Alberta. In 2011, he received his designation from the Institute of Corporate Directors (ICD.D) and in 2008, he received a Life Membership in the Institute of Chartered Accountants of Alberta in recognition of his dedication, commitment and service to the profession over a period of 40 years.

Mr. Gilpin has served on the boards of Canada Health Infoway, Search Canada and Afexa Life Sciences Inc. He currently serves on the boards of the Institute of Health Economics, Health Quality Council of Alberta, Burcon NutraScience Corporation, and The Inspections Group Inc. Mr. Gilpin retired from the partnership of KPMG LLP in 1999 after serving as an audit partner in the Edmonton Office for 18 years.

ARLENE DICKINSON

Ms. Dickinson, owner and CEO of Venture Communications, a company she grew from a small, local firm to one of the largest independent agencies in Canada, is also the CEO of District Ventures and Youinc.com. Companies all aimed at helping market, fund and grow entrepreneurs and entrepreneurial companies. She is a two times best-selling author, accomplished speaker and is best known to Canadians as one of the venture capitalists on the award-winning CBC series' Dragons' Den.

Arlene's leadership has been recognized with honours including Canada's Most Powerful Women Top 100, the Pinnacle Award for Entrepreneurial Excellence, as well as PROFIT and Chatelaine's Top 100 Women Business Owners and, is a Marketing Hall of Legends inductee.

She is an Honorary Captain of the Royal Canadian Navy and the recipient of honorary degrees from Mount Saint Vincent University, Saint Mary's University and the Northern Alberta Institute of Technology. Arlene sits on the Leadership Council of the Perimeter Institute for Theoretical Physics, several boards including the Omers Venture advisory board, and is the proud recipient of The Queen Elizabeth II Diamond Jubilee Medal.

JOERG GOETSCH

Mr. Joerg Goetsch is the General Manager of Corporate Affairs for Daishowa-Marubeni International Ltd. (DMI), which is one of the top bleached kraft pulp mill producers in North America. Mr. Goetsch also serves as President of the Peace River Logging Corporation, a successful partnership between DMI and the Woodland Cree First Nation.

Mr. Goetsch is an experienced operational leader and collaborative team partner with the strategic vision for leveraging new technology and industry best practices to help innovate and grow business opportunities.

He is an active member of the forestry community having participated on senior level cross business steering committees and industry specific thought leadership groups with a goal of sustainably managing and diversifying the forestry sector. He has a demonstrated track record of developing and implementing initiatives in areas such as forest management, optimizing production operations, cost management and environmental stewardship.

Mr. Goetsch has also been on the Board of Directors for Alberta Innovates – Bio Solutions for the last five years, advancing Alberta's BioEconomy Initiative.

CHRIS HENSHALL

Dr. Henshall is a Professor in the Health Economics Research Group at Brunel University and works as an independent consultant in health, research and innovation policy. Previous appointments in Alberta include Board Director of the Alberta Research and Innovation Authority (ARIA) from 2010 to 2015 and Board Director of Alberta Innovates Health Solutions from 2015 to 2016.

Dr. Henshall has held senior positions in the British Government and university systems. From 2005 to 2010 he was Pro Vice Chancellor at the University of York with responsibility for enterprise and innovation and links between the University, regional and national government and industry. Prior to that he was Director of the Science and Engineering Base Group in the Office of Science and

Technology in the Department of Trade and Industry in London, where he was responsible for around \$5 billion U.S. annually of government support for research and innovation.

Earlier in his career, Dr. Henshall served as Deputy Director of Research and Development in the Department of Health and the National Health Service (NHS) where he led the creation of an NHS R&D budget and was closely involved in establishing the NHS Health Technology Assessment (HTA) Program and the National Institute for Clinical Excellence (NICE). Dr. Henshall was the founding President of Edmonton-based Health Technology Assessment International (HTAi) and the founder and Chair from 2004 to 2007 and 2010 to 2016 of its HTA Policy Forum which brings together senior figures from life sciences companies and public health systems from around the world.

GORDON LAMBERT

Mr. Gordon Lambert retired from Suncor Energy on January 1, 2015. He is currently the Suncor Sustainability Executive in Residence at the Ivey School of Business and has established GRL Collaboration for Sustainability as a consulting practice. He is an advisor and frequent speaker on energy, the environment and innovation. He was instrumental in the creation of Canada's Oil Sands Innovation Alliance (COSIA) and in 2014, was a speaker on Innovation and Collaboration at the World Economic Forum in Tianjin China. In 2015-16 he has been a member of the WEF Global Council consisting of 1200 people globally who help shape the future agenda of the organization including its work on the Future of Oil and Gas.

With Suncor Energy Gord served as the VP Sustainability and in 2013, he was appointed Executive Advisor Sustainability and Innovation where he supported the CEO, senior executive team and the Board of Directors. He has 36 years experience in the energy sector including 17 years with Suncor, two years with TransAlta and 15 years with Imperial Oil. He was a recent member of the Alberta Climate Leadership Advisory Panel to the Environment Minister and the Premier.

OUR BOARD

MARCELA MANDEVILLE

Ms. Mandeville believes strongly in contributing to the community. In addition to various board, committee and general volunteer commitments, she has shared her story and advice through speaking engagements including the Famous Five Foundation Speaker Series, Women's Executive Network Breakfast Series, and the Women in Leadership Aboriginal Forum. It is her passion to support organizations and causes that make a difference.

In 2015, Marcela resumed a leadership role at Alberta Women Entrepreneurs (AWE). She is very proud to work alongside the AWE team to support women entrepreneurs and their valuable contributions to the economy.

Ms. Mandeville holds an international business degree with a focus on marketing, a designation as a Certified International Trade Professional, an MBA, and more than 15 years of global experience in business strategy and planning, marketing, communications and project management.

PATRICIA MCLEOD

Ms. McLeod is committed to Alberta and has a passion for public service. She has a strong background in complex board governance with public and not-for-profit sectors. She is presently a Director on the provincial Beverage Container Management Board, and also serves on the Boards of Chestermere Utilities and of Calgary Co-op. She previously held board positions with YWCA Calgary (as Chair) and served in executive Board capacities for Calgary Economic Development.

Ms. McLeod developed a strong understanding of cultural change management and innovation during her time at AltaLink where, as an outcome of her MBA studies, she helped to implement the company's internal process to encourage innovation.

Ms. McLeod understands complex regulated and deregulated environments, has experience in change management, strategic planning, enterprise risk management, and solid business acumen.

ROHIT SHARMA

Mr. Sharma is a proud product of the Alberta technology innovation and education system. As an engineering graduate student at the University of Alberta and TRILabs, his research work in the field of Digital Communications led to a collaborative work with the National Research Council. Mr. Sharma extended his work in fiber optics into a PhD program with TRILabs and University of Alberta. The industry-university collaborative research environment in Alberta has served as a cornerstone of his skill-set professionally.

Upon completing his PhD, Mr. Sharma was recruited to join a Stanford University spin-out company in silicon-valley, followed later by his launch of ONI Systems, a start-up optical networking company powered by a core set of employees including several from Canada. As Founder & CTO, Mr. Sharma led the technology development of world class Metro fiber optics communication systems for the company. In 2000, ONI had a successful IPO, and two years later it was acquired for \$900 million by Ciena, the world's third-largest telecom company.

As an investor with True Ventures, a leading bay area venture capital firm, Mr. Sharma continues to be deeply ingrained into the Silicon Valley founder-led ecosystem of technology innovation. His industry exposure extends across all aspects of the broad ICT sector and his board responsibilities include industrial and chemical applications of genomics and new optical manufacturing technologies. His collaboration network extends into India through his investment in India based startups and venture funds. He is loyal to Alberta and appreciates how the innovation system in the province launched and shaped his career. In 2004 he endowed a professorship in Digital Communications at the University of Alberta to support research and technology development in Alberta.

ANNE SNOWDON

Dr. Snowdon's experience is at the nexus of research, public policy development, health system innovation and commercialization. She holds a patent for a safety innovation in child car seats, and her expertise in the health care systems of most Canadian provinces and is expected to bring valuable best practices to Alberta Innovates.

Dr. Anne Snowdon is a Professor of Strategy and Entrepreneurship and the Chair of the World Health Innovation Network (WIN), at the University of Windsor, Odette School of Business. Dr. Snowdon leads the work of the first Canadian health innovation centre with formal ties to the U.S., building collaborative partnerships between the two countries to contribute to advance the health of populations, accelerate health system innovation in both countries to achieve sustainability, economic value and productivity by providing support for innovators and entrepreneurs to successfully bring their discoveries to the Canadian, U.S. and world markets.

Currently, Dr. Snowdon is leading over 15 innovation research initiatives across seven Canadian provinces that collaborate with government, health professionals, private industry, foundations and families. She was a member of the Ontario Health Innovation Council and currently the Chair of the Institute Advisory Board for the Institute for Human Development, Child and Youth Health, of the Canadian Institutes for Health Research (CIHR). She has also been appointed to the President's Advisory committee on digital health innovation at CIHR.

She is also an Associate Professor to the adjunct academic staff of the School of Rehabilitation Therapy at Queen's University, Adjunct Faculty at the Department of Computer Science at the University of Windsor, and Adjunct Faculty at the School of Nursing at Dalhousie University.

Dr. Snowdon has published more than 100 research articles, papers and cases, has received over \$15 million in research funding, holds patents, and has commercialized a highly successful booster seat product for children traveling in vehicles. She holds a PhD in Nursing from the University of Michigan. She is a Fulbright Scholar and was awarded the Social Sciences and Humanities Research Council Doctoral Fellowship for her research.

TOM THOMPSON

Dr. Thompson is well known and widely recognized for his contributions to education, sports, marketing and community services. Now in his 15th year as President at Olds College, Dr. Thompson has taken a leading role in post-secondary education for over thirty years. Dr. Thompson is recognized for serving on numerous initiatives to enhance education, leadership, governance, entrepreneurship, and community service. Most recently, Dr. Thompson and Olds College were honoured with the World Federation of Colleges and Polytechnics Gold Award of Excellence in Governance.

Public speaking engagements have extended Dr. Thompson's influence and brought recognition to Olds College and Alberta's post-secondary system. Dr. Thompson obtained his Doctorate in Higher Education Administration, with a policy governance research focus. His professional development continues with completed educational and leadership programs at Harvard, Oxford, and the WestPoint Academy. He currently lends his expertise to numerous community, provincial and national boards and committees while providing visionary, forward-thinking leadership to Olds College.

PROJECT LIST

ENERGY TECHNOLOGIES

AACI Program

Acid Enhanced Bitumen
Visbreaking

Application of New Gas
to Liquids Technologies to
Reduce Emissions, Phase 2

Assessment of Partially
Upgraded Bitumen Emissions
at Refineries

Canadian Centre for Clean
Coal/Carbon and Mineral
Processing Technologies
(C5MPT)

Catalytic Light Olefin
Upgrading Using Natural
Gas for Gasoline Quality
Improvement

Canadian Clean Power
Coalition, Phase 5

Comparative Test on Oil
Drainage Behaviour under In
Situ Vapor Solvent Extraction

Eastern Canadian Market
Access

Economic Analysis and GHG
Benefits of Cogeneration at
a SAGD Facility

Energy Efficiency Field Study:
Application of Best Operating
Practices in Alberta's Oil and
Gas Sector

Field Demonstration of
Advanced Membranes for
Syngas Cleanup and CO₂
Capture

Hydrocarbons in
Nanochannels: Understanding
Transport in Shale

Institute for Oil Sands
Innovation (IOSI)

Natural Sciences and
Engineering Research Council
(NSERC) Foundation CMG for
Reservoir Simulation Chair

NSERC Foundation CMG
Industrial Research Chair in
Reservoir Geomechanics for
Unconventional Resources
Chair

NSERC Industrial Research
Chair in Petroleum
Microbiology

NSERC Industrial Research
Chair in Oil Sands Engineering

NSERC NEXEN Chair in
Bitumen Upgrading

NSERC/AERI Industrial
Research Chair in Petroleum
Thermodynamics

Opportunities to Improve the
Competitiveness of Alberta's
Oil Sands Products for U.S.
Refineries

Oxy-fired Pressurized
Fluidized Bed Combustor
Technology Development (P2)

Partial Upgrading Background
Review

Technology Development
for Viscosity Reduction
of Bitumen for Pipeline
Transportation: H-donor
Assisted Visbreaking

Testing Hybrid Bitumen
Extraction Process

Tight Oil Consortium

Unconventional Oil and
Gas Innovation Roadmap

U.S. Oil Sands Athabasca
Bitumen Processing Test

RENEWABLES AND EMERGING TECHNOLOGIES

Alberta Energy Research
Facility Centre: Conversion
from Methanol to Ethanol

An Organic Waste Inventory
for Alberta

Assessment of Municipal Solid
Waste (MSW) Utilization for
the Town of St. Paul

Conversion of Tri-Municipal
Region Organic Waste to
Bio-Energy

Deep-Dive Analysis of the
Best Geothermal Reservoirs
for Commercial Development
in Alberta

Developing Alberta's
Geothermal Reservoirs
with EGS-CO₂ Method

Development of a Waste
to Energy Decision Analysis
Model for a Municipality in
the Province of Alberta

Distributed Lithium-Ion
Storage for Demand Charge
Reduction

Edmonton Municipal Waste
P3 Biowaste Demo

Electrochemical Engineering
Innovation by Combining
iF Cathode Technology
with Porous Silicon Anode
Technology for Advanced
Battery Commercialization

Energy Storage in Alberta and
Renewable Energy Generation

Feasibility of Converting MSW
into Liquid Fuel using a Novel
Methanolysis Process

Identification of Best Energy
Efficiency Opportunities in
Alberta's Chemical Sector,
Phase 4

Lethbridge Landfill Drill
Sample Methane Potential
Measurements and Molecular
Characterization

Liverpool Wind and
Regenerative Air Energy
Storage Project

NSERC/Cenovus/Alberta
Innovates Associate Industrial
Research Chair in Energy
and Environmental Systems
Engineering

Redox Flow Battery Innovation
for Large Scale Electrical
Energy Storage

Zinc-Air Fuel Cell for
Renewable Energy Storage

WATER AND ENVIRONMENTAL MANAGEMENT

A Comparative Toxicity Assessment of Diluted Bitumen to Sour and Sweet Crude Oils

Advanced Approaches to Dealing with Water Disinfection Byproducts

Alberta Applied Biodiversity Conservation Chairs

Alberta Land Institute - Wetlands Research Strategy for Alberta

Arsenic in Rural Alberta's Ground Water

Assessing the Ecological Impacts of Water Extraction on Stream Hydrology and Alberta's Fish Community Structure and Function

Assessing Water Quality, Microbial Risks and Waterborne Pathogens in Rural Alberta using a One Health Framework

Atmospheric Metal Deposition in Northeastern Alberta

Atmospheric Organics Deposition in Northeastern Alberta

Baseline Isotope Geochemistry of Alberta Groundwater

Canadian Water Network 2015-16 Hydraulic Fracturing Program

Ceramic Membrane Deoiling and Desilication

Climate Vulnerability and Sustainable Water Management in the South Saskatchewan River Basin: Part of the Watershed Stewardship and Ecosystem Management Focus Area

Creating a Predictive Ecosystem Classification Platform for Alberta: P1 Feasibility Assessment, Technology Development and Piloting

Development of a High Efficiency Mechanical Vapour Compression (MVC) Evaporator for SAGD Application

Due Diligence Assessment of Proposed Carbon Capture Technologies

Economics of Adaptation to Extreme Hydrological Events

EKS Electro Kinetic Remediation Work Program Phase Two

Enhancing Accessibility and Use of Alberta's Natural Water Recreation Areas through Prevention of Swimmer's Itch Transmission

Evaluation of Existing Legal Instruments to Promote Integrated Water Management Decision Making

Evaluation of Integrating a Molten Carbonate Fuel Cell (MCFC) with SAGD Facility

Expanding Wastewater Reuse in Alberta through Application of a Quantitative Microbial Risk Assessment Framework

Functional Flows: A Practical Strategy for Healthy Rivers

InLine Dewatering of Oil Sands Tailings

Investigation of the Occurrence of Pesticides in Groundwater of Southern Alberta

LiDAR: Wet Areas Mapping Linear Corridors Forest Recovery Project

Mammalian and Zebrafish Toxicity of Raw and Physico-Chemically-Treated Oil Sands Produced Water

Membranes for CO₂ Capture: FSC-PVAm Membrane

NSERC Chair Advanced Oxidation of Oil Sands Process-Affected Water: Process Fundamentals

Nutrient Status and Retention in Reconstructed Sandy Soils

Oil Sands Tailings Geotechnique Chair

Perceptions of Water Quality among Rural Albertans and Association with Livestock

Predicting Alberta's Water Future

Pre-FEED to Test Post Combustion CO₂ using MCFC

Quantifying Groundwater Recharge for Sustainable Water Resource Management

Redevelopment and Enhancement of the Irrigation Demand Model as a Tool for Basin Water Management

Resolving Natural and Anthropogenic Influences to Groundwater and Surface Water Environments in the Lower Athabasca Region

Study on Current State of Research into Maritime Spills

Sustainable Urban Water Management in the Context of Climate Variability and Change

Sustainable Water Management in the Athabasca River Basin Initiative (The ARB Initiative), Phase 2

Sustainable Wetland Habitat: Reclamation Targets, Design Criteria and Wetland Policy Implementation

Titanium Membrane De-Risking Project

Towards Integrated Source Water Management in Alberta

Water Reuse and Management of SAGD Processed Waters

Web-Based Monitoring System - Enhancing the Provincial Mapping and Monitoring Capability



Building on Alberta's strengths to diversify our economy, improve environmental performance and enhance our well-being.

Partner with us to innovate faster.

albertainnovates.ca

