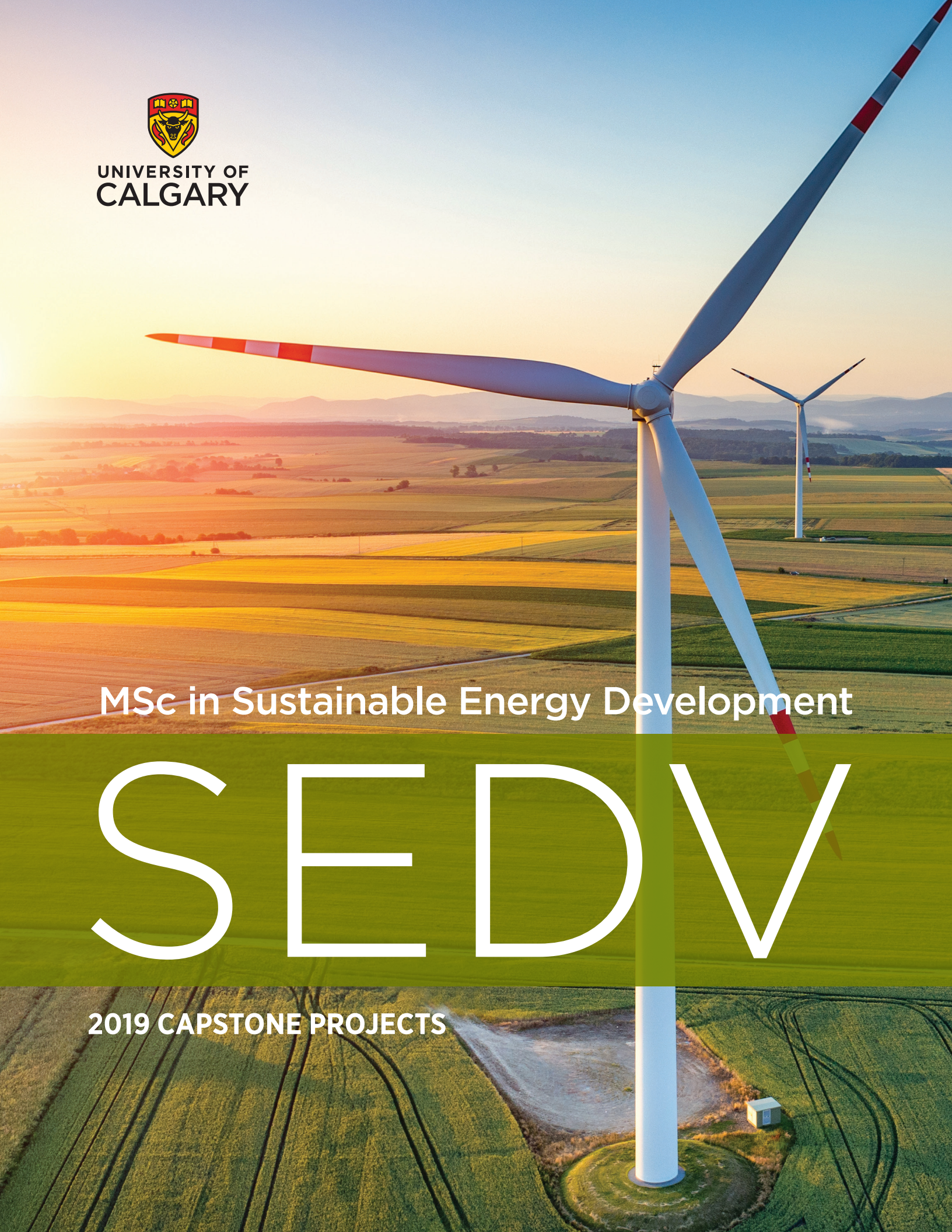

UNIVERSITY OF CALGARY

MSc in Sustainable Energy Development

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Algae Cultivation System as Wastewater Treatment Solution in Wheatland County

Adeyinka Adelodun

An integrated approach to manage the water, food and energy nexus is essential as impacts of climate change emerge and the complexities of wastewater increases. This project evaluates the energy, environmental and economical implications of using microalgae to treat wastewater in Wheatland County, Alberta. Results demonstrate that wastewater effluent that meets discharge regulatory requirements can be produced using an Algae Cultivation System (ACS) with significant Green House Gas emissions reduction when combined with Hydrothermal Liquefaction (HTL) System for microalgae biomass to biocrude conversion. However, my analysis finds that the volume of biocrude produced is not enough to operate the HTL at full capacity and it would require aggregating other sources of biomass to operate at full capacity. Lastly, I also conclude that externalities must be considered in wastewater treatment cost, and the capital expenditure of deploying ACS and HTL must be lower for economical viability of this solution.

Barriers and Incentives for Residential Solar PV in the Calgary Area

Elshan Bagherzadegan

Solar energy holds great promise for reduction of greenhouse gas emissions, especially in sunny places such as the Calgary area. While its cost has decreased and its efficiency has improved, there is no proportionate increase in adoption. An increase in adoption not only reduces environmental concerns but has potential benefits for the economy. In this capstone project, I analyze the barriers and incentives for solar photovoltaic (PV) adoption by residents in the Calgary area. Specifically, I conduct a survey to better understand the residents' motivations and concerns. I perform statistical analyses on the data using t-test and regression analysis. I find that age, salary, and other factors have significant impacts on adoption. Moreover, I emphasize the importance of looking at the adoption decision more holistically, and considering factors such as lifestyle and environment, along with economic factors. Based on my analyses, I provide several recommendations for policy-makers and companies.

CCUS Potential for Mexico's Energy Security within Its Climate Change Mitigation Targets

Leonardo Conde Fernández

Climate change poses an unprecedented threat for the international system, menacing the most vulnerable elements of societies, and hindering ecosystems' stability and viability of their biological components. Currently, the Paris Agreement to which Mexico is a member state, offers a framework to foster countries' efforts to reduce greenhouse gas emissions and mitigate global warming. Mexico historically has based its energy security on the exploitation of oil resources but now it requires to bolster a sustained energy transition to comply with this international accord, as well as to reduce its vulnerability to climate change. Carbon capture use and storage could be a strategic tool to help Mexico to approach its reduction targets, while improving its energy security in order to pave the way for an effective energy transition. This research examines this premise by looking into the existing demonstration projects of CO2 sequestration in Mexico.

Closed-Loop Cryptocurrency Mining in Alberta

Monika Silvia Enachescu

In the highly connected age of information and data, the push for the development of 'clean data' has necessitated sustainability strategies for data centers. Green innovations are increasingly implemented to reduce the formidable power consumption of inefficient computing processes while heat reuse solutions repurpose the large volumes of server waste heat, decreasing facility footprint. This project examined the efficiency optimization potential of co-located power generation and greenhouse waste heat reuse for cryptocurrency data center platforms in Alberta. The proposed 45 MW data center capitalized on favorable climatic conditions to reduce energy requirements, improving facility efficiency and decreasing theoretical PUE values from 2.13 to 1.51. Resultant waste heat sufficiently supplied year-round heating to an 8.34-acre greenhouse suitable for commercial cannabis growth. The total annual avoided emissions for this proposed system were calculated at 70,000 tonnes of CO2, illustrating the potential of integrated economizer cyles and waste heat reuse in Alberta.

Evaluation of Cumulative Environmental Effects on the Endangered Southern Resident Killer Whales

Theresa Chicote

With only 74 members left, the Southern Resident Killer Whales (SRKW) of the Salish Sea, are endangered under the Canadian Species at Risk Act (DFO, 2018) and the United States Endangered Species Act (US EPA, 2017). The Trans Mountain Expansion Project became a nationwide topic when the Project approval was overturned by the Federal Court of Appeal in August 2018, who cited lack of review of the predicted noise increase and its subsequent effects on the SRKW. This research study identifies the threats affecting the SRKW, assesses marine vessels that impose a cumulative noise effect, and suggests mitigation methods to manage traffic and minimize adverse effects on the SRKW. By corresponding with industry professionals, reviewing published literature and analysing case studies, it was concluded that no matter how small an increase of marine traffic in the SRKW critical habitat, it is significant considering the vulnerable state of the SRKW population.

Examining Carbon Challenges in the Western Canadian Forestry Industry: A Review of Current Forest Carbon Accounting Practices and Forest Management Issues.

Joshua Mitchell

Considering the increased international emphasis on the role of forests in climate change mitigation efforts, it is important to examine the challenges facing forest management regimes as they begin integrating regulations for forest carbon and climate change values. Large-scale natural disturbances and a business-first regulatory approach have contributed to forests in British Columbia and Alberta devolving from perennial carbon sinks into net carbon emission sources. An examination of provincial forest management regulations and policies suggests that current forestry regulations in western Canada don't adequately consider forest carbon issues and may fall short of international sustainable forest management standards. This issue is highlighted by the permissive regulation of slash burning, a practice which simultaneously destroys usable forest fibre while significantly contributing to forest sector emissions. Potential regulatory solutions to slash burning are examined, and potentially misleading transparency issues regarding carbon accounting practices in the LULUCF sector of Canada's National Inventory Report are discussed.

Feasibility Analysis for the Implementation of Solar PV Technology in a Day Care Facility in Calgary

José Leonardo Villegas Mora

Photovoltaic power is becoming an attractive energy source option for small businesses. As a base case, I collected electrical energy and natural gas monthly data from Little Worlds Learning Centre, a day care facility in Calgary, for the calendar year of 2018. I considered two possible scenarios. For Scenario A, I considered only the electricity consumption, and for Scenario B, I considered the consumption of electricity and natural gas. For each scenario, using RETScreen, I designed a photovoltaic system that would produce, in a one-year period, approximately the equivalent energy as was used in the year 2018. In my design and analysis, I considered aspects, such as, photovoltaic technologies available in the market, installation and maintenance costs, greenhouse gas emissions and economic incentives from the Alberta Government, among others. My analysis indicates that only Scenario A is economically feasible and has an associated greenhouse gas reduction of over 90%.

Food Waste at the Grocers in the City of Calgary

Manashri Shejwalkar

Food waste impacts the environment, energy, economy and society. Grocery stores are a powerful link between consumers and farmers. This influential position imparts a huge responsibility on them to reduce food waste. My research question is “How can the grocers in the city of Calgary help reduce food waste?”. National research conducted by the Second Harvest Foundation formed the baseline for the project. Local primary data were collected from the grocery stores through an online survey to find the reasons for food waste and barriers to implementing a food waste reduction strategy. Even though the sample size was small, the comparison with the national survey revealed that the major reasons for food waste are similar locally and nationally. A multifaceted issue like food waste needs collaborative solutions; hence recommendations were included for both the grocers and local government to help reduce food waste and food insecurity in Calgary.

From Nixon to Trump: Energy Policy in the Global Era

Alexander Leon McQuaid

From 1970 to 2011 the United States underwent a 20% increase in trade as a percentage of GDP. International trade growth has complicated the accurate estimation of cumulative environmental effects while necessitating increased political entanglement. The current U.S.-China trade war illustrates this complexity. Current trade talks include, but are not limited to ‘decoupling’ the two nations and the ‘reshoring’ of U.S. manufacturing. If decoupling were to occur the United States would also be reshoring the energy demands and the ecological impacts of greater goods production. This paper evaluates this possible shift in terms of its impact on environmental and energy policy. It considers the causes for economic and political entanglement during this period, and the need for policy adjustments. To this end, this paper ultimately argues that the United States government ought to fund global multi-regional input-output (MRIO) studies in order to better inform environmental and energy policy.

Improving the Pre-Project Planning Scouting Framework for Oil and Gas Projects in Colombian Amazon with Light Detection and Ranging (LiDAR): Interdisciplinary Case Studies from the Putumayo Department of Southern Colombia

Kyle Stephan Snarr

The western Amazon is arguably one of the most challenging environments for oil and gas development worldwide. Sustainability issues consistently contribute to project delays, and cost and schedule overruns. This research aimed to improve decision making quality in the front-end phase of projects through the integration of disruptive technology into robust decision making frameworks. A high resolution Light Detection and Ranging (LiDAR) dataset collected over the Andean-Amazon foothills of southern Colombia was integrated into the scouting framework for seismic, well pad, and pipeline programs. Using case studies, LiDAR was demonstrated to reduce uncertainty and risk of social, cultural, and environmental aspects of the landscape and help identify impact reduction opportunities using industry best practices. Features identified included buildings, infrastructure, streams, wet areas, and possible archaeological features. The avoidance and mitigation of material sustainability risks was improved with the use of LiDAR in the complex and sensitive Colombian Amazon landscape.

Integration of Advanced Biofuel in Alberta

Cameron Young

Increasing production of biofuels is one way for Canada to meet its Paris Agreement targets on greenhouse gas emissions. The production of advanced biofuels from residual biomass is an area of growing interest. Steeper Energy has developed technology for producing an advanced biocrude using hydrothermal liquefaction and has tested methods to upgrade said biocrude into usable liquid fuels. Alberta already has a substantial refining infrastructure, which can coprocess biocrude along with oil distillate products. Co-processing can reduce the cost of producing biofuels from residual biomass by leveraging existing processes in a refinery. Coprocessing in fluid catalytic crackers and hydrotreaters in Western Canadian refineries could coprocess up to 53,000 BPD of biocrude. A lifecycle greenhouse gas intensity assessment found biofuel produced using hydrothermal liquefaction approximately 60% less greenhouse has intensive than diesel produced from crude oil.

Investigation into Using EPAnet Software to Design Trickle Fill Water Distribution Systems

Katerina Zhdyreva

Small rural drinking water systems in Alberta face financial challenges when supplying potable water via traditional pressurized distribution system. In many rural settings, the costs can be reduced by employing an innovative solution of distributing and delivering water via low-pressure water supply system, often called trickle fill system. This research develops a modelling approach to design the trickle fill system in Rockyview County, Alberta and investigates into EPAnet software application suggested by US Environmental Protection Agency to study and analyze system hydraulics, water quality, and energy profile. The conducted research concludes the trickle fill system design cannot be performed by EPAnet alone and suggests modeling software applications suitable for rural water development to be used in combination with EPAnet software. The study proposes options for energy optimization for Rockyview County and finds that trickle fill system implementation is the most suitable option.

The Irony of Climate Science and the Race to Net Zero: A Carbon Footprint Investigation

Catherine MacKinnon

A carbon footprint investigation of the Kluane Lake Research Station (KLRS), which supports the advancement of climate science, is vital to identify the organization's large-scale contribution to climate change. A comprehensive measurement of KLRS's emissions profile enables the development of effective mitigation and management strategies to approach net zero carbon, in alignment with current IPCC projections. The GHG Protocol Standard was applied to evaluate KLRS's material emission sources and understand its energy demands and environmental impacts, supplemented with an economic analysis of mitigation efforts addressing its predominant direct contributor. The findings yielded 86 percent of KLRS's absolute emissions were scope 3 with 86 percent attributable to aviation, emphasizing the importance of decarbonization, extensive behavioural change, and global collaboration essential to progress this fundamental exploration whilst minimizing its impact. This signifies a critical juncture in addressing climate science's ironically high carbon signature and the synergistic pursuit required to realize carbon neutrality.

Optimization of Waste Collection System at University of Calgary

Samira Farahbakhsh

This project addresses the following question: How can the existing waste collection system at the University of Calgary be optimized to be more aligned with the sustainability concept. The University of Calgary hosts 30,000 to 35,000 people each day. Each resident produces 0.1 tons of waste per year, which is equivalent to 3,000 tons of waste annually. This magnitude of waste requires an efficient waste collection system. To find inefficiencies along with improvement opportunities the existing collection system has been studied and compared with other collection systems used in other universities. The result shows a short-term and a long-term optimization proposal. The short-term proposal suggests a 34 percent and the long-term one leads to 24 percent cost reduction mainly by reducing the number of waste collection truck pick-ups. In addition, both scenarios demonstrate the environmental and social benefits, such as greenhouse gas reduction and opportunities for waste education.

Redwater Energy Appeal: The Supreme Court Judgment and its Impact on the Oil and Gas Industry

Christine Melodie Nahas

This research aims to address the implications following the Supreme Court of Canada's Redwater Energy Appeal on the oil and gas industry. End-of-life activities for energy development present billions of dollars in liabilities in the western provinces of Canada for social, economic and environmental mitigation. This study investigates the potential consequences of the ruling through a qualitative analysis using a data sample consisting of eighteen participants from Alberta, British Columbia, and Saskatchewan, who are affected by the decision. To progress in a positive, and environmentally conscious economy, the concerns from important stakeholders in the energy sector must be recognized for future changes in liability management programs. The results suggest government intervention, education, a reworking of the current liability management system, and amendments to federal legislation.

Residential Solar PV Standard in Alberta

Thomas McGoey

Alberta is one of Canada's most attractive jurisdictions for solar PV deployment because of the resource availability. Alberta's recent regulatory environment, which included attractive incentives that encouraged residential solar PV deployment and installation, resulted in tremendous growth in solar PV systems (1 MW in 2009 to 45 MW in 2017). This paper examines whether a residential solar PV standard in Alberta should be implemented, and what role a standard could play in increasing uptake and deployment of solar PV systems. The research includes an examination of minimum accreditation required for residential installations, the impact of having consistent regulatory approaches throughout the province, and what incentive policies could result in sustained residential solar PV development. Through reviewing policies and approaches used in other jurisdictions, this project aims to provide recommendations for a regulatory environment in Alberta which does not introduce additional barriers for consumers and installers and improves the industry's reputation.

Reversible Solid Oxide Fuel Cell Technology for Carbon Utilization in Alberta

Abraham Omar Masri

Alberta's economy is heavily dependent on the oil & gas sector, and with increasing concern over climate change and global warming from anthropogenic CO2 in the atmosphere, there is an urgent need for decarbonizing the economy. Progress toward decarbonization has been made with the Alberta Carbon Trunk Line facilitating carbon capture, utilization and storage; however, additional clean-technology for carbon utilization is required to reduce greenhouse gas emissions while allowing continued oil production to meet the growing energy needs of the world. This study analyzes three models assessing Reversible Solid Oxide Fuel Cells (RSOFCs) in Alberta as a carbon utilization technology, with the ability to use waste CO2 while producing fuels, and chemicals; or as means to generate clean electricity. This study seeks to ascertain the environmental, economic, and energy, implications of this technology. The findings indicate that the technology is economically valuable, while providing environmental benefits and substantialenergy applications.

Small Nuclear Reactors in Canadian Remote Communities: a Cost Benefit Analysis

Ross O'Connor

In northern Canada, there are over 280 communities that are home to approximately 200,000 people who are neither connected to the electric grid nor the natural gas pipeline system. The idea of using nuclear small modular reactors (SMR's) has been invoked as a possible solution to meet the ongoing energy challenges of remote northern communities. This paper intends to look at the feasibility of using SMR's in Canada's northern remote communities instead of dieselpowered generators. This study analyzes the life cycle cost benefit analysis of a small modular reactor in a northern indigenous community of approximately 1000 people in comparison to the existing alternatives of diesel-powered electricity generators and natural gas.

A Sustainable and Multi-Operator Approach to Water Management in Unconventional Oil and Gas Developments

Sergio Ballesteros

Unconventional oil and gas developments are causing significant footprints resulting from freshwater use, temporary water infrastructure and the greenhouse gas emissions associated with water hauling truck trips. These status quo industry practices can also prove costly to oil and gas operators. The present study explores the economic and environmental benefits that exist when permanent water infrastructure is planned at scale using entire water life cycle considerations. Focusing on an area of study west of Grand Prairie, AB, the author demonstrates the economy of scale of such a development and proposes that this opportunity is more easily captured when two or more operators collaborate through a multi-operator water management plan (MOWP). This framework prompts regulatory and business model challenges that would need to be addressed but in the light of climate change, increasing water management costs and water security considerations, MOWPs are nothing but an opportunity to be seized.

Which communities would most benefit from retraining workshops for skilled trades people of the fossil fuel industry to transition to renewable technologies?

Nicholas Alexander Kendrick

The fossil fuel industry has propelled Alberta's economy for decades, however periods of prosperity are often followed by low oil prices. With the world striving for low carbon energy solutions, tradespeople must equip themselves with skills to adapt to evolving socio-economic and environmental conditions. Iron & Earth is an NGO committed to empowering fossil fuel workers and Indigenous people to diversify Canada's energy mix through retraining workshops. This research investigates optimal locations to deliver solar installation workshops by utilizing a weighting matrix using 4 parameters: proximity to utility solar projects, transitioning coal communities, Indigenous populations, and absent training opportunities. Additionally, Alberta's capacity for new solar workers is explored and the impact of these workshops is measured. Results suggest that there is no perfect area that completely satisfies all 4 parameters however, many rural counties are identified that would be attractive for Iron & Earth to approach to best serve Albertans.

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Contact us

University of Calgary
MSc Sustainable Energy Development Program Office
2500 University Drive NW
Calgary, AB T2N 1N4
CANADA

+1.403.220.2013
sedv@ucalgary.ca
ucalgary.ca/sustainableenergy