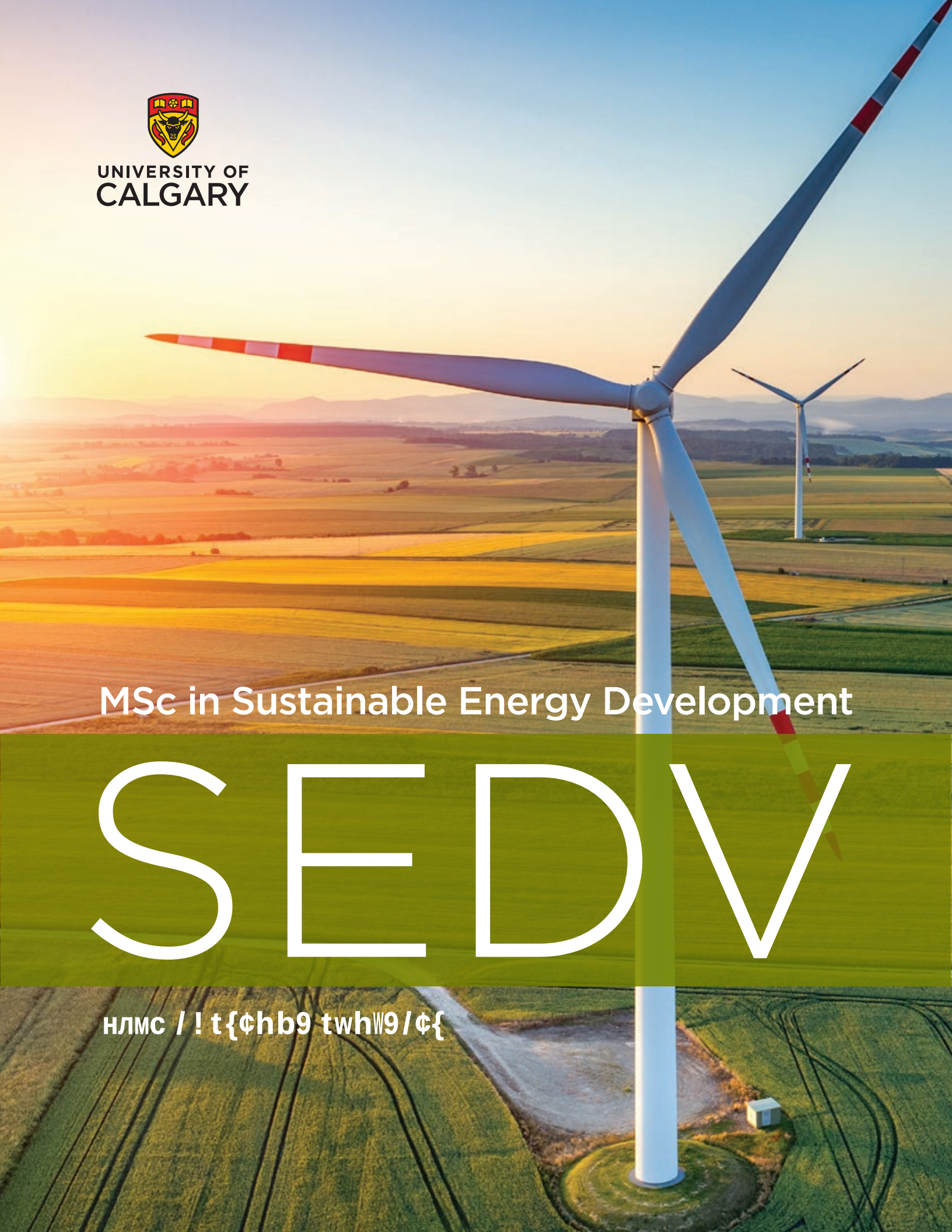
UNIVERSITY OF
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2016 CAPSTONE PROJECTS

Benefits of Building Resealing and Lighting Fixture Renovation

Thomas Philip

Approaches reducing energy usage are identified for university residence buildings in this project, and applied in an analysis for a particular building, namely Olympus Hall, University of Calgary. It is proposed that building resealing and lighting fixture renovation are effective techniques to reduce energy consumption. Three dimensions are considered for each technique: actual (before) and estimated (after) energy consumption, carbon dioxide emissions, and the estimated simple payback period. The proposed resealing of Olympus Hall would result in an estimated 46.66% reduction in annual heating energy use with a payback period of 8 years and 8 months. The proposed replacement of the T12 lighting system with a T8 lighting system at Olympus Hall would produce an estimated 31.2% annual electrical energy savings with a payback period of 3 years and 7 months. Applying both approaches results in an estimated total carbon dioxide emission reduction for Olympus Hall of 39.75% annually.

Carbon Price Sensitivity Analysis on the Alberta Oil Sands: An Environmental and Economic Study

Tooraj Moulai

This paper provides an overview of the oil sands industry including the associated environmental impact, Alberta's greenhouse gas (GHG) regulations, and the economics of bitumen production. The impact of the GHG regulations is examined using the emissions intensity of the oil sands industry relative to the provincial GHG reduction targets. The economic impact of GHG regulations on industry is analyzed by determining the average cost of compliance per barrel of bitumen produced. For comparison, the carbon pricing systems in British Columbia and Norway are discussed and the outcomes of the policies are provided as examples of the impact of higher carbon pricing and more stringent regulations. Norway's relatively high carbon price is applied to Alberta and the economic implications are discussed. Through these analyses and findings, a number of policy recommendations for Alberta's GHG regulations are provided to address the environmental issues of the industry while considering important economic factors.

Coal and the Ideal Electrical Energy Source Combination: Alberta's Climate Leadership plan

James Caldwell

The Alberta Climate Leadership plan is an expansive policy framework that will impact Albertan's in the way they use and produce energy and conduct their business activities. This research aims to discover what the ideal electrical energy source combination should be and how it should be developed to replace coal-fired energy under the goals and the constraints of the Climate Leadership plan and its associated policies. A detailed literary and document review has been performed to identify the necessary background, the potential policy risk and technical information for identifying and comparing an idealized electrical energy source combination. Results indicated that the phase out of coal-fired energy under the Climate Leadership plan is achievable. Success will be dependent on the province of Alberta's ability to garner the necessary capital investment and the ability of the Alberta Government to adapt to a changing social and economic environment.

A Comparative Analysis of Liquid Cooling Mechanisms for Photovoltaic Systems

Sean Hazen Gorman

Photovoltaic energy has the potential to provide clean and renewable energy to many countries around the world, especially in areas with high solar irradiance. However, in regions with particularly hot climates, elevated PV cell temperatures reduce conversion efficiency. In this study, four different liquid cooling mechanisms for photovoltaic systems are reviewed and compared in terms of energy yields and environmental implications. The science behind these technologies is explored to give a better understanding of how they work and how they can be improved in the future. Results show that submerged photovoltaics and front surface water cooling provide the greatest increase in energy yield, while back surface cooling and evaporative cooling methods provide significantly lower energy yields than suggested in previous works. There are potentially significant environmental impacts associated with submerged photovoltaics on marine environments.

A Costa Rican Power Security Strategy for 2030 using Distributed Generation in the Industrial Sector

Alonso Alegre

Costa Rica faces constant energy demand growth and environmental concerns for mega-power developments. The aim of this research was to determine if distributed generation might reduce the installation of mega-power plants in Costa Rica. As an alternative proposal to mega-power projects, Costa Rica's industrial sector in an urban area might fulfill its own electricity requirements through to 2030, by installing photovoltaic modules in a distributed generation system. My proposal is that distributed generation will represent 6% of Costa Rica's electricity consumption in 2030. This proposal could potentially replace six future mega projects, including two thermal plants. By eliminating these plants, Costa Rica might reduce its carbon footprint, thereby pursuing its carbon neutral goal by 2100. However, regulatory aspects represent a significant challenge for introducing distributed generation in the national grid. My research has determined that distributed generation is technically and environmentally beneficial within Costa Rica's power security strategy.

Development of a Photovoltaic System for an Off-Grid Commercial Complex in the Cayman Islands: A Life Cycle Carbon Footprint and Energy Payback Investigation

Peter Tseng

A life cycle assessment was conducted for a commercial-scale polycrystalline photovoltaic system located in the Cayman Islands in order to determine the net carbon footprint and energy payback of the system. The carbon emissions across the life cycle stages included within the system boundaries of the study was found to range between 45 to 77 gCO2/kWh. The system possesses a substantially negative carbon footprint, offsetting much more carbon than what is emitted during its lifecycle. The gross energy requirement of the life cycle stages included within the system boundaries of the study was found to be 1,027.35 MWh. Based on the projected annual generation of the photovoltaic system, the energy payback time of the system was calculated to be 1.74 years and the energy return factor to be 17.29. The implementation of PV technology may add social value to the Cayman Islands by strengthening energy security and boosting the local economy. Overall the photovoltaic system examined was favourable for installation from both environmental and energy perspectives. It is therefore recommended for implementation in the Cayman Islands.

An Economic Assessment of Using Aqua Pure Technologies' PROH2O® System to Treat Produced Fluids from Hydraulic Fracturing Operations for Reuse in Alberta, Canada

Jeffrey Coombes

As conventional forms of oil and gas mature, unconventional resources are becoming desirable. Unconventional resources, found in tight rock formations, require hydraulic fracturing to extract the resource. Large quantities of water are required and produce vast amounts of contaminated wastewater. Currently, wastewater must be locked away permanently, deep underground. This paper provides an economic assessment of using Aqua Pure Technologies' PROH2O® system to treat wastewater for reuse. The aim is threefold; can the impact on water resources be reduced, can cost savings be achieved, and should Dragos Energy Corporation initiate investment in the technology? To complete the economic assessment, a hypothetical hydraulic fracturing operation is modeled and analyzed. Although a number of assumption have been made to complete this analysis, the author shows that the technology can be used to create significant economic and environmental benefits which could lead to a competitive advantage Dragos Energy Corporation.

Economic Feasibility and Sustainability Dimensions of Recovering and Composting Food Waste from Canadian Natural Resources Limited (CNRL) Horizon Site's Work Camps.

Adriana Zuniga

The purpose of this study is to determine if it is environmentally sustainable and economically feasible to recover and compost the food waste from Canadian Natural Resources Limited (CNLR) Horizon work camps. Then CNRL could use the compost produced as part of the land reclamation process. CNRL is situated 75 kilometres (km) north of Fort McMurray, Alberta. Thus, the research project identifies the in-vessel aerobic system as the option for the weather conditions found in this remote location, and complications that arise from the compost attracting wildlife or workers encountering wildlife. The food waste data was obtained and analyzed using an international greenhouse gas (GHG) emissions protocol. The results compared the GHG emissions from the disposal of food waste in the landfill, with the proposed composting facility. The anticipated outcome shows a theoretical reduction of GHG and related GWP emissions of up to 20,503 tonnes CO2e per year. The findings may be useful for carbon emission reduction credits, as proposed by the Alberta Government, and decrease operating expenditures, as well as enhancing CNRL's corporate and environmental reputation.

Effect of Snow on Solar Photovoltaic Systems in Alberta

Namrata Sheth

Alberta lies in the highest irradiance regions of Canada and has a cold climate which makes it the best candidate to expand its installed solar photovoltaic capacity. Alberta's Climate Leadership Plan to shut down coal generated electricity is another motivation to develop renewables like solar PV. However, there is a significant amount of snow in Alberta, which may hinder the electricity generation ability of photovoltaic systems. The primary objective of this paper is to find the effect of snow on electricity generation by photovoltaic systems in Alberta. A photovoltaic system is set up in Calgary for the experimental research. The result is there is a 9% loss in energy yield per year due to snow accumulation which is quite an insignificant loss considering the analysis is in the absence of bypass diodes.

Effects of Optimized Business Management on Renewable Energy Technology Start-up Organizations

Nicholas Ritchie

Renewable Energy (RE) technology can meet growing energy demand and mitigate negative environmental effects. Start-up businesses that develop RE technologies may face unique challenges such as unequal subsidization and taxation of different energy sources. This project answers the question "How can innovation be facilitated in start-up technology organizations in the renewable energy production sector so that environmental performance and sustainable practice can be further developed?" Methods for investigation include a literature review of research on business management practices, interviews with RE professionals and environmental and market data obtained from other research. It was found that RE companies are similar to other businesses but face longer development timeframes and require large amounts of startup capital. Demonstrated leadership, company value alignment, relationship development and deliberate and proactive business planning were found to be ways that start-up RE companies can avoid premature failure.

Feasibility of Using Natural Gas Cogeneration for Greenhouse Power, Heating and CO2 Enrichment

Andria Panidisz & Hannah Wentzell

Cogeneration technology, known for energy efficiency, low energy costs and low greenhouse gas (GHG) emissions, generates both heat and power. Carbon dioxide (CO2) is also produced and is typically vented. However, the potential exists to use the CO2 to promote plant growth in a greenhouse. The objective of this evaluation is to determine whether a one - megawatt (MW) natural gas cogeneration unit is a technologically, environmentally and economically feasible method to provide power, heat and CO2 enrichment to the Blood Tribe Agricultural Project's (BTAP) proposed greenhouse. Furthermore, to assess the feasibility in using light - emitting diode (LED) lights to further enhance energy efficiency. Through data collection and analyses, this evaluation will compare technologies, determine GHG emission reductions and corresponding carbon offset credits, determine natural gas requirement reductions for heating, and assess financial feasibility. Ultimately, the research concludes that cogeneration is not preferred for BTAP's proposed greenhouse, but offers recommendations for future research.

Free, Prior and Informed Consent: International Context and its Reflection in Alberta

Cristina Belen Vallejo Suarez

This project compares several international documents about Free, Prior and Informed Consent (FPIC) with the United Declaration on the Rights of Indigenous Peoples (UNDRIP), and determines the possible changes in the Alberta Regulations and Guidelines for consultation with aboriginal peoples, regarding oil and gas projects. This involves the analysis of the Alberta Consultation Policy and Guidelines and the study of the background of indigenous peoples rights in under the Canadian and international context. The perspectives of experienced professionals involved in the oil and gas industry, and aboriginal consultation process, are also included. The result of this analysis shows that even though Alberta recognizes aboriginal and treaty rights in the regulations, their guidelines are situated in a good position regarding the Free and Informed principles, the province will have to adapt their policy and guidelines to be more in line with the Prior and Consent Principles, to be fully aligned with UNDRIP.

Integrating Renewable Energy in Alberta: An Examination of Electricity Cost Impact of the Proposed Climate Leadership Plan

Abhijith Seetharam

Alberta's Climate Leadership Plan is perhaps the most ambitious undertaking for curbing carbon emissions and promoting renewables in the province. This study evaluates cost of electricity generated under the proposed plan where 30% of the electricity is sourced from renewables, and estimates the emission reduction against a business-as-usual scenario. The feed-in cost of electricity generated is computed by working out asset mix, electricity output and transmission costs under different scenarios. Assuming that the existing renewable facilities continue to generate electricity at current levels, the study reveals the Climate Leadership plan's carbon mitigation target can be met by sourcing 30% of the electricity from wind. Meeting the emissions reductions target would result in 11% to 60% increase in the cost of electricity generated as compared to the Baseline scenario, depending on whether it is sourced from wind or PV respectively. Under the Climate Leadership plan GHG emissions are projected to reduce by 18 megatonnes vis-à-vis baseline scenario.

An Investigation of the Energy, Environment and Social Impacts of the Informal Electronic and Electronic Waste Recycling Industry in the Guangdong Province of China

Christina-Joy Derrick

High consumer demand and obsolescence of technology has led to the growth of a major global issue: electrical and electronic waste, otherwise known as e-waste. The global production of e-waste is expected to grow an average of four percent per annum, creating a mounting problem for developing countries, such as China, as the developed world ships its unwanted e-waste under the guise of recycling. A major culprit is the United States, which exports 27% of its e-waste to China, where it is processed using crude methods. Such techniques have resulted in heavy metals and persistent organic pollutants contamination of the air, land and water. The quality of life for e-waste recycling communities in the Guangdong Province has been drastically reduced due to the degraded environmental conditions and the resulting health issues.

Investment and Environmental Attractiveness in the Absence of Government Subsidies

Stephen Cole

Renewable energy alternatives are often subject to criticism with respect to relying on government subsidies. In considering the merit of this criticism it is necessary to examine the definition of subsidies and consider how the details impact renewable energies from a microeconomic decision making level. It becomes apparent that the existing energy infrastructure has been the recipient of subsidies that have evolved into government policies and are now over looked. To further sustainable decisions for investment in the electricity market thei mpact of select subsidies on different energy sources is undertaken. The goal is to determine if renewable options can compete with coal in the absence of subsidies. The analysis is foccused on coal, wind, and geothermal resources available in Alberta. The analysis shows the market distortion of price support subsidies, which encourages investment in projects that provide incremental results, whereas strong policies can foster long-term growth in an industry.

Methane Emissions Regulations in Western Canadian LNG: Realizing Opportunities for Success
Jillian Kareema Haneiph

Liquefied natural gas (LNG) presents an opportunity for transitioning the global economy to a less-carbon intensive one. LNG enables the transport of a clean-burning energy alternative to coal and oil from supply to demand markets. The entrance of Western Canada to the global LNG market has the potential to bolster the national economy while improving the environmental performance of the global economy. The development of western Canadian LNG requires diligent management of methane emission concerns to ensure climate change commitments are met. This study investigates the economic costs and benefits of methane emissions reduction opportunities in Western Canada and how enforcing these through regulation may affect the region's competitiveness in the global LNG market. Porter's Hypothesis is used as a framework for analysing the potential impacts of increasingly stringent methane emission regulations on the business performance and innovation of the Western Canadian LNG industry and recommendations are made accordingly.

Moving beyond the Moratorium: A Future for Hydraulic Fracturing in Quebec
Karla Palardy

This paper provides an overview of the energy debate in Eastern Canada in both New Brunswick and Quebec. In particular, the proposed development of hydraulic fracturing in the St Lawrence Lowlands of Quebec and the provincial moratorium on fracking in 2011. The situation came to a turning point following the BAPT report on the development of hydraulic fracturing in Quebec. As a result, Quebec has effectively shut the door on this type of energy development. The purpose of the proposed project is to examine the reasons why this difference in perception may exist and the specific issues of concern through content analysis. Through this content analysis, recommendations are provided on appropriate stakeholder relations strategies using existing frameworks.

Power of the Individual: Saving Energy through Conscious Consumption
Lidia Sorial

The purpose of this study is to capitalize on an opportunity to become more sustainable. The points in question are: How much energy savings can be achieved through conscious consumption alone? What changes are people willing to make at their own discretion? Are there any correlations between certain demographics and energy use? Experimental results from 10 households showed that the minimum savings achieved over one month are equal to a potential annual savings of 250,000 GJ of natural gas, 43 million kWh of electricity, and 5 million m3 of water across Calgary. Water-related changes were the most commonly applied by participants. Successful households had more members, more kids, slightly higher education levels, more awareness in reality, and less awareness by perception compared to their less successful peers and the applicable statistics. Overall, energy-saving tips were deemed an effective mechanism by which to notably reduce energy consumption in an urban setting.

Practical considerations to implementing a state-of-the-art air emissions management system to improve environmental compliance for energy companies in Western Canada
Oleksiy Golovchenko

Overall goal of this project was to identify practical considerations to implementing advanced air emissions inventory management system. Understanding the nexus between regulatory and data driven considerations is of paramount importance for successful implementations of environmental management information systems.

No less important is the actual selection of EMIS based on clearly defined business and regulatory requirements. Concise summaries of these requirements were focused on upstream oil and gas companies with operations in Western Canada. As there is virtually no available academic literature on the topics of EMIS design and selection, the author considered it his obligation to cover the subject matter in greater detail. Particular emphasis is on datadriven considerations, which include practical examples of various data elements, system workflows and automations. It is hoped that lessons learned from this work will be used by organizations in their efforts to select and implement a state-of-the-art air emissions inventory management system.

Preliminary Feasibility Study of the Capture of Methane in an Ecuadorian Palm Oil Mill Effluent Treatment for the Generation of Energy

Ana Melissa Urquía Mendoza

The Palm Oil Industry is one of the leading agricultural industries in Ecuador, with a planted area of 280,000 has and a national production of 500,000 tons of Palm Oil, around 50% of the national production is exported (PROECUADOR, 2014). As the industry of palm oil has expanded, so has its environmental impact, with the deforestation, methane emissions and other impacts caused by the cultivation of Oil Palm and its processing (Raquel, 2005). National and International entities have highlithed the industry's impact on biodiversity and climate change (Gobi & Vadivelu, 2013). The process of extracting oil from the fresh fruit bunches result in large generation of palm oil mill effluent (POME), a highly polluting wastewater (Raquel, 2005). Due to the environmental concerns regarding palm oil production, POME has been identified as a potential source of renewable energy from the generation of biogas in the wastewater treatment system (Hosseini & Wahid, 2013). The environmental concern around Palm Oil has led to the creation of certifications that guarantee the sustainability throughout the production process of Palm Oil, an example of this is the RSPO which is leading the environmental awarness of this industry (Roundtable on Sustainable Palm Oil, 2015). This paper aims to discuss the presence of methanogenic activity in the POME treatment system and the possible use of this substance as a source of energy. Moreover, it aims to analyze the technologies available for this purpose. Finally, an economic analysis is performed to determine the financial feasibility of the generation of electricity using methane.

A Review of the Proposed Carbon Competitiveness Regulation: A Cost Effectiveness Approach to Reducing Oil Sands Emissions.

Joeti Lall

Climate change has resulted in progressively adverse impacts resulting in an increase in stakeholder pressure for reducing greenhouse gas (GHG) emissions. The Alberta oil sands contribute to almost 10% of Canada's GHG emissions. The Carbon Competitiveness Regulation has been proposed to reduce emissions directly related to Alberta oil sands production. This paper (1) explores the cost effectiveness of adopting the new regulation through literature review and data analysis, (2) identifies the challenges of reducing emissions, and (3) develops recommendations to improve the policy process. An environmental analysis is presented to uncover the emissions related to the oils sands, followed up a policy critique of the proposed regulation, and a data assessment of the potential economic costs related to implementing it effectively. The proposed regulation appears to be a cost effective approach to reducing emissions, but faces challenges including oil prices, market conditions, technology availability, and carbon leakage risks.

Technical and Economic Considerations of Power Generation from Solution Gas in Alberta

Maria Margarita Meza Rios

This research explores the potential for power generation from solution gas in Alberta, seeking to meet an increasing energy demand, contribute to the coal phase-out, and reduce flaring. Estimation of this potential is based on the analysis of technical and economic challenges associated with power generation, including volumes of solution gas available, its variability of production and quality for combustion, as well as available technologies and market conditions. The results of this study show that there is a potential for 127 MW power generation from the solution gas that is flared in the province and that gas production variability and quality do not limit its development. Current electricity pool price does not favor the implementation of the project but it still represents an economic alternative for flaring reduction when there is on-site demand or displacement of other fuels. Finally, 684 thousand tons of CO2 equivalent can be offset by flaring reduction.

Unleashing Local Capital in Greening Alberta's Grid: An Evaluation of a Co-operative Investment Model to Stimulate Renewable Energy Development in Support of Alberta's Climate Leadership

Colin Rioux

Never before has a co-operative business model been attempted in Alberta in stimulating community economic development using renewable electricity generation and local capital. Given Alberta's depressed power prices and economy, and the political challenges of an energy transition, the success of a renewable energy investment co-operative is unknown. The Alberta Solar Co-op (ASC) was incorporated as an Opportunity Development Co-operative in February, 2016, to provide Albertans direct investment opportunities in Alberta's renewable energy future. The co-op model is well suited for sustainable development, including electricity. While many jurisdictions world-wide have demonstrated this, Alberta lags. The ASC is developing Alberta's first community owned, 2-megawatt solar farm. This study finds that government support in the form of a $2 million grant and an energy credit approximating $90/megawatt-hour may provide member-investors a positive financial return on their investment – and provincial and municipal governments, a social, economic, and environmental return on theirs.

Urban Agriculture in Mumbai: Worth Its Weight in Produce?

Christiane Joi Allen

This study uses Life Cycle Assessment and Cost Benefit Analysis to evaluate the environmental, social and economic benefits of implementing urban agriculture into a major city in a developing country, in this case Mumbai, Maharashtra, India. Environmental impacts are assessed by a comparative Life Cycle Assessment of urban agricultural practices to commercial large scale agriculture. The assessment of social and economic benefits through cost benefit analysis takes into consideration the unique social and economic situations of agricultural practices in the Mumbai and Maharashtra. Results indicate that urban agriculture has lower greenhouse gas emissions, energy consumption and water consumption but higher eutrophication potential compared to commercial large scale agriculture.

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