Future Energy Systems 2021 Research Symposium

20 September 2021 - 24 September 2021

Abstracts and Proceedings

Oral Presentations

Alternative Fuels	
The techno-economic assessment of alternative materials for hydrogen production via photocatalytic water splitting	Hydrogen (H2) can play a critical role in global greenhouse gas (GHG) mitigation. Photocatalytic water splitting using solar radiation is among the promising H2 technologies. Titanium dioxide (TiO2) and graphene (g-C3N4) based photocatalysts are the most widely used photocatalytic materials because of their activity under visible light and abundance in the earth's crust. Several attempts have been made to improve the photocatalytic performances of those materials in terms of their activity levels; life spans; responses to visible radiation; and stabilities. However; evaluation of the economic viability of large-scale deployment of those modifications is scarcely addressed in the existing literature. This study; therefore; aims to develop a bottom-up techno-economic assessment framework to determine the cost of hydrogen production of four alternative pathways. The results suggest that TNR has the lowest cost at 4.9 $/kg of H2 and a payback period of 0.8 years.
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Study of physical mixtures of Ir and metal oxide supports for water splitting applications	Supported catalysts befittingly form the backbone of heterogeneous catalysis for laboratory and industrial scale. The use of supports is critical for improved performance of the catalyst as it offers high dispersion; higher surface area; higher resistance against leaching; & aggregation of NPs. Electronic and geometric interactions between a metal oxide support and the noble metal-supported on them termed “strong metal-support interactions (SMSI)”; can alter; & at times improve the performance of the catalyst. The purpose of this study is to detect SMSI in physical mixtures; using Ir as active metal and commonly used metal oxide supports. The knowledge obtained from this study will be used to synthesize better-supported catalysts for laboratory scale and commercial proton-exchange membrane water electrolyzer (PEM-WE); and subsequently boost green hydrogen production in the long term; a major step in the development of zero-emission fueling systems and mitigation of climate change.
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Exploring biomass and heavy oil co-processing enabled by copper catalysis	Biomass valorization and green hydrogen production are two key planks in the ongoing transition to a low-carbon economy. We have designed a novel heterogeneous copper catalyst that seamlessly straddles these two research areas; harvesting hydrogen from internal hydroxyl residues in biomass and using that hydrogen to drive the depolymerization of lignin into monocyclic aromatic compounds. This internal transfer hydrogenolysis proceeds under remarkably mild conditions; and completely avoids the use of hydrogen generated from traditional fossil fuel sources. Critically; this 'hydrogen harvesting' strategy can be coupled with reductive processing of polycyclic aromatic molecules found in heavy oil; creating potential opportunities for co-processing of biomass and heavy oil into commodity petrochemicals and transportation fuels.
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Jeffrey M. Stryker; Department of Chemistry; Faculty of Science; University of Alberta	
Developing genetic tools for Methylomicrobium album BG8: a versatile microbial platform	Methanotrophic bacteria can convert methane; a greenhouse gas and cheap carbon feedstock; to value-added chemicals like isoprenoids; precursors of high performance fuels. Methylomicrobium album BG8 is a methanotrophic bacterium notable for its fast

for conversion of methane to isoprenoids	and robust growth and rich genetic potential; making it an excellent candidate as an isoprenoid bioproduction platform. In this context; development of functional genetic tools for M. album BG8 can enable strategies for increased isoprenoid productivity. We showed that the broad host range vectors IncP; IncQ and pBBR1 can be conjugated and propagated successfully in M. album BG8. We tested four constitutive promoters and two inducible promoters using GFP expression as a proxy. Experimentation has moved to the controlled expression of catechol 2;3 dioxygenase;. a functionally active protein. The combination of these promoters and vectors can enable us to control biochemical pathway involved in isoprenoid production in M. album BG8.
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Steam Explosion and Enzymatic Digestion with Sugar Recovery as Pretreatments for Cellulose Nanocrystals Production	The industrial process to produce bioethanol from lignocellulosic biomass requires an advanced cellulase cocktail to depolymerize the recalcitrant crystalline region of cellulose to fermentable sugars. These enzymatic approaches are often associated with high costs due to the high cost of cellulase cocktails. Therefore; to offset such economic challenges; biorefinery strategies need to be designed that provide high fermentable sugars recovery with additional high value-added products from lignocellulosic biomass. The crystalline regions of cellulose are precursors for a nanostructured material called cellulose nanocrystals (CNCs); and the amorphous chains can be hydrolyzed to sugars and subsequently fermented to ethanol. In this study; a steam explosion pretreatment combined with enzyme and acid hydrolyses were exploited to co-generate CNCs (at an increased yield) and fermentable sugars from poplar wood chips.
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Mechanistic investigation into the formation of humins in acid catalyzed liquid phase biomass reactions.	Humins are formed during acid-catalyzed reactions of biomass-derived carbohydrates to furanic compounds. Such by-products account for 10-50% of carbon loss in the feed and deactivate the catalyst. Investigating humins formation is challenging due to their complex and unknown molecular structure. Likewise; during the condensed phase catalytic conversion of biomass; variety of reactions occur simultaneously; making it difficult to isolate humins formation reactions. Hence; in this work; quantum mechanical Density functional theory (DFT)-based calculations are performed to compute reaction pathways and activation barriers associated with the key steps in the acid catalyzed reactions leading to humins formation. This research open new avenues to understand the formation of humins; since detailed mechanistic insights and quantification of the energetics can lead to the modification of reaction conditions to alter the formation of humins.
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Electronic Delocalization of Bismuth Oxide Induced by Sulfur Doping for Efficient CO2 Electroreduction to Formate	Developing efficient electrocatalysts for electrochemical CO2 reduction (ECR) to fuels and chemicals with high product faradaic efficiency (FE) and current density is desirable but remains challenging. Herein; S doped Bi2O3 electrocatalysts coupled with carbon nanotube (S-Bi2O3-CNT) are synthesized for efficient ECR to formate. The obtained S2-Bi2O3-CNT (with S doping amount of 0.7 at%) is highly active for formate production (FE> 90%) over a wide current density range (2.77 mA cm−2 – 48.6 mA cm−2) and a maximum formate FE of 97.06 % can be achieved at – 0.9 V. The significantly enhanced selectivity and activity is originated from the fast electron transfer; enhanced CO2 adsorption and more undercoordinated Bi sites induced by the S doping.
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Engineering product selectivity in CO2 photoreduction using bimetallic plasmonic nanoparticles on oxide supports	CO2 photoreduction mimics artificial photosynthesis by converting CO2 and water into hydrocarbon fuels using solar energy. High product selectivity in CO2 photoreduction is advantageous in reducing the need for post-reaction purification steps. A key goal is to produce longer chain hydrocarbon (C2+) products that have a greater energy density and higher economic value than C1+ products such as methane; methanol and formaldehyde.

Rajashekhar, Harshitha **hrajashe@ualberta.ca** Ehsan Vahidzadeh; vahidzad@ualberta.ca; Faculty of Engineering; Karthik Shankar; kshankar@ualberta.ca; Faculty of Engineering	However; the C-C coupling barrier is a formidable obstacle that has thus far prevented C2 products such as ethane and ethanol from being the dominant products of CO2 photoreduction. Our research shows that large bimetallic plasmonic nanoparticles on metal oxide supports are able to overcome the C-C coupling barrier. This talk will show our latest results in this regard and briefly discuss the underlying mechanisms that promote C-C coupling in heterojunctions of nanostructured metal oxides with bimetallic plasmonic nanoparticles.
Reactive Distillation for Synthesis of Dimethyl Ether Using Bio-Methanol from a Kraft Pulp Mill **Dar, Danish** **DanishD@nait.ca** Dr. Paolo Mussone; PMUSSONE@nait.ca; Applied BioNanotechnology Industrial Research (ABNIR) - NAIT Industry Solutions	Dimethyl Ether (DME) has significant potential for large scale use as a low emission automotive fuel; for power generation; and as an intermediate for the petrochemical industry. Methanol recovered from the Kraft pulping process constitutes as a potential feedstock for the direct synthesis of low-carbon intensity; renewable DME. One alternative to cleaning or incinerating the bio-methanol is to convert it into a high value chemical such as DME. In this work we present the simulation; physical design; and rating of a reactive distillation column to study this chemical reaction at the pilot scale under industrial conditions using a sulfur-rich methanol recovered from a Kraft pulp mill in Alberta. We simulated the reactive distillation column using Aspen Plus© software and optimized the design through sensitivity analysis on varying parameters. Using simulation results; we designed and constructed a 2 inches diameter and 12 feet in height column equipped with process control features.
Hydrocarbons	
An Integrated Assessment of Deep Decarbonization Pathways for the Canadian Oil Sands **Younis, Osama** **oyounis@ualberta.ca** Matthew Binsted; matthew.binsted@pnnl.gov; Joint Global Change Research Institute; USA; Dr. Evan G.R. Davies; evan.davies@ualberta.ca; Department of Civil and Environmental Engineering; University of Alberta; Muhammad-Shahid Siddiqui; muhammad-shahid.siddiqui@canada.ca ; Economic Analysis Directorate; Environment and Climate Change Canada; Evan J. Arbuckle b; ejarbuck@ualberta.ca; Department of Civil and Environmental Engineering; University of Alberta; Diego V. Chiappori ; chiappor@ualberta.ca ; Department of Civil and Environmental Engineering; University of Alberta	Canada; a party to the Paris Agreement; has proposed an ambitious climate target of net -zero emissions by 2050. The country holds the world's third largest oil reserves in the Alberta oil sands. In 2017; the oil sands sector employed 140;000 people; had a capital investment of 21 billion USD; and accounted for 11% of national greenhouse gas emissions. Achieving Canada's net-zero emission target requires significant decarbonization of the oil sands sector. In this study; using the Global Change Analysis Model (GCAM); we explore the sector's evolution; under a deep decarbonization context; across a range of future technological scenarios and international mitigation pathways. We find that Canadian unconventional oil production is highly dependent on the availability of lower carbon-intense extraction technologies in addition to the international demand for oil. Negative emission technologies could play a role in maintaining the demand for oil in deep decarbonization scenarios.
A Dynamic Economic Analysis of oil sands process-affected water (OSPW) treatment alternatives	Alberta’s Oil Sands are the World’s 3rd largest proven oil reserve. About half of current extraction is by open pit mining; which generates Oil Sands Process Water (OSPW); a complex mixture of solids; residual bitumen; inorganics; and organic constituents. As part of their obligations; Oil Sands companies must treat the OSPW to reclaim the land and

in Alberta	water disturbed by their activities; however; there are still obstacles and unanswered questions around this objective. This study aims to estimate the amount of OSPW that will accumulate by the end of each mining project; its characteristics (i.e. Naphthenic Acids; Total Dissolved Solids; Toxicity) and cost of alternative treatment options including active and passive technologies. A mathematical programming model will be built to identify trade-offs among cost-effective technologies; and show how alternative regulatory standards might affect technology choice; costs and optimal timing of OSPW treatments
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Grant Hauer; Vic Adamowicz; Mohamed Gamal El-Din; M. Anne Naeth; Pamela Chelme-Ayala	
Energy Media: The Politics of Solid-Phase Bitumen	In 2017, three Canadian firms unveiled competing techniques for transforming bitumen extracted from Alberta's oil sands into solid, self-contained units. It is well known that transportation of diluted bitumen and other hydrocarbons from Alberta to North American markets and tidewater ports has been a matter of recent and ongoing political contention in Canada, often expressed in disputes over the infrastructures of this transportation. Solid-phase bitumen is thus a material intervention in the politics surrounding the transport, or mediation, of bitumen by pipelines and tankers, and therefore the politics of Canada's resource economy and the environment more generally. In solid, solid form, bitumen pucks, pellets, or butter can be poured into containers, trucks, railcars and ships for relatively safe, long distance terrestrial and marine transportation to continental or offshore markets for both combustion (fuel) and non-combustion (asphalt) products. For this reason, solid-phase bitumen has been presented as a technical solution to the various environmental and political hazards involved in the transportation of liquid oil. This presentation introduces the SSHRC-funded project "Energy Media: The Politics of Solid-Phase Bitumen." The project employs documentary research, site visits, and media and interview-based analysis to examine the political, economic and environmental implications of this innovation. The emergence of solid-phase bitumen is examined in terms of the politics of "format," whereby competing formats invoke storage, transport, standards and infrastructure as sites of economic, commercial and environmental advantage, negotiation and contestation. The project also inquires into whether and how changes in the material techniques of containing and transporting bituminous oil might affect the complex relationships between industry, government and diverse publics surrounding this contested resource and its environmental implications.
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Effects of low-temperature hydrothermal treatment on the properties and removal of fine solids from nonaqueous extraction bitumen	A major drawback of Non-Aqueous Extraction processes is the high fine mineral solid content of the bitumen product. In this study; a combination of low-temperature hydrothermal treatment; venting; and room-temperature filtration was investigated to clean the NAE bitumen. The combined treatment was found to be an effective method for solids removal from NAE bitumen as the filtration time decreased dramatically. Without the hydrothermal treatment; the NAE bitumen was unfilterable. Bulk chemical analysis showed that the carbon content of the fine solids was reduced when hydrothermal treatment was conducted. This suggests the possibility of stripping off some adsorbed organic species from the fine mineral solids by subcritical water. Results revealed that the fine mineral solids agglomerated after hydrothermal treatment; which suggested that removing organics from the surface of the fines caused their stability to be disrupted and triggered fines agglomeration; facilitating filtration.
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Removal of hydrophobic bitumen-coated fine solids from NAE bitumen	This work aims to modulate the interfacial chemistry of solid/oil and oil/water interfaces to alter the wettability of fine solids and their interactions with the water drops; through the addition of bio-inspired polymers and polysaccharides; to facilitate the aggregation of the fine solids and water drops and further to enhance the sedimentation. Through sedimentation tests and analysis using focused beam reflectance measurement (FBRM);
Santander, Camila	

csantand@ualberta.ca Xiaoli Tan; Qi Liu; Hongbo Zeng	we demonstrate that natural gums can facilitate the settling of the bitumen-coated solid particles in cyclohexane. The interaction between water drops and solids with the presence of gums was quantified through surface force measurements using atomic force microscope; supports our findings. The solid content in the oil phase (supernatant) after settling demonstrates that about 87% of the fine solids were removed. This work proposes a feasible method for the removal of fine solids from diluted bitumen without using synthetic additives in NAE process.
Separation and Oxidation Strategies for Developing Novel Asphaltene-Derived Feedstocks **Le, Katelyn** **katelyn.le@ucalgary.ca**	The use of Alberta oil sands byproducts in non-combustion technologies is environmentally and economically advantageous; however; their complexity poses a barrier towards their competitiveness as a source material. In support of oilsands byproducts as a functional feedstock; we sought to develop a library of well-characterized asphaltene materials modified through unconventional solvent extraction or additionally by selective oxidation; both of which manipulate industrially relevant qualities including molecular composition; vanadium content; and thermal behaviour. Using our data; efforts have begun towards a machine learning platform that elucidates the relationship between pretreatment and resulting structural changes; we intend for this platform to predict suitable pretreatments given the desired properties of an asphaltene material. Together; our library and predictive platform support the exploration of asphaltenes in new energy technologies such as carbon fibers and batteries.
Surface-modified magnetite nanoparticles for removal of fine solids from nonaqueous extracted bitumen **Liu, Xuyang** **xuyang2@ualberta.ca** Kaipeng Wang; kaipeng@ualberta.ca; Faculty of Engineering; Xiaoli Tan; xiaolit@ualberta.ca; Faculty of Engineering; Qi Liu; qliu@ualberta.ca; Faculty of Engineering	Magnetite nanoparticles (MNP) and surface-modified magnetite nanoparticles including SC-MNP; SAA-MNP and Asp-MNP (i.e.; MNP modified by sodium citrate; stearylamine acetate; and asphaltene respectively) were prepared to capture fine solids and remove them from NAE bitumen product through magnetic filtration. Results demonstrated that SAA-MNP and Asp-MNP could remove 89% and 84% of fine solids from cyclohexane-diluted bitumen (CDB) respectively; while the removal efficiency of MNP or SC-MNP was only about 16%. After one cycle of use; SAA-MNP and Asp-MNP maintained almost the same removal efficiency; but the efficiencies of MNP and SC-MNP improved significantly to 79% and 78%; respectively. Meanwhile; D(10)s; D(50)s and D(90)s of all above nanoparticle aggregates in cyclohexane were getting smaller. These may be due to the modification of nanoparticle surfaces by CDB; which not only improved their affinity to the suspended fine solids but also dispersed the nanoparticle aggregates.
Bitumen Extraction by Using Non-thermal cyclic solvent process **Yousefi, Mohammad** **myousefi@ualberta.ca** Taregh Soleiman Asl; solieman@ualberta.ca; Faculty of Engineering	The main objectives of this study are to: i) understand the interaction between bitumen-propane at the bulk-phase at low temperature; ii) evaluate the solubility of propane in the bitumen at low temperature; and iii) investigate bitumen extraction mechanisms by liquid propane from an artificial sand pack during injection; soaking and depletion phases. We conduct novel visualization experiments by using a custom-designed; state-of-the-art high-pressure and high-temperature (HPHT) visual cell. The experimental results show that using a non-thermal cyclic solvent process; not only is effective in the oil-recovery; but also it can reduce the need of steam injection to recover the viscous bitumen in the oil-sands reservoirs. The outcome of the study can help the industry toward the future goal of the net zero emission by substituting thermal oil-recovery methods; therefore decreasing the greenhouse gases emission during thermal heavy oil production operations.
Real-time monitoring of Oil Sand Pipelines by Wireless Communications **Khajepour, Somayeh**	Real-time monitoring of oil sand pipelines is our final aim. So to derive this goal; we had to design a wireless battery free structure to monitor SAGD pipelines. We focus on creating sensor arrays distributed at critical locations along the slotted liner. We presented a wireless power and data transfer system to power a large number of sensors and transfer their data to the surface by developing a RFID based system for real time monitoring of

skhajehp@ualberta.ca	SAGD pipeline environmental parameters such as temperature (which is about 300°C); pressure and humidity. As these sensors and tags are going through underground; providing power for them would be crucial. They could be supplied by wireless power transferring method. So designing a battery free RFID tag is required. Another critical parameter is operation frequency which determines the loss of communication link between tag and reader. So the array of tags and readers would be placed on the pipeline to provide real time SAGD pipeline monitoring.
Instability of parallel flow of two immiscible liquids in a pore and application to Steam-Assisted Gravity Drainage	The instability at the interface between two parallel flows of immiscible liquids through a uniform planar pore is studied by using linear stability analysis. A characteristic equation determines the growth rate versus wavenumber and instability conditions are determined. The instability is governed by a dimensionless group relating the ratio of gravity to interfacial tension. Interfacial tension has a stabilizing effect resisting the destabilizing gravitational force, limiting the range of wavelengths of unstable disturbances to be longer than a minimum critical wavelength. Application to flow of steam condensate and mobilized bitumen in the SteamAssisted Gravity Drainage (SAGD) process shows that the instability is possible only over a specific range of temperatures given the densities of the steam condensate and oil in the reservoir. This instability may help in forming an emulsion that could help support oil drainage if the oil is hosted by the more mobile water phase.
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Landscapes	
Electrical Resistivity at Mount Meager; Southwestern BC: A Volcanic Geothermal Prospect	The Garibaldi volcanic belt in British Columbia is part of a ring of volcanoes around the Pacific Ocean. There is potential to produce electricity from hot water in geothermal reservoirs beneath these volcanoes. Mount Meager is the most active volcano in this belt and steam vents have become visible in recent years. Major landslides have also occurred nearby. Geothermal research at Mount Meager since the 1970s suggests that a power plant could be economic. To reduce the economic risks of development; more information about the geothermal reservoir and natural hazards is needed. This can be obtained from geophysical studies of the subsurface. Magnetotelluric data were collected in 2019 and 2020 in the region around Mount Meager. They were used to generate a 3-D model of electrical resistivity; a property that is sensitive to the presence of fluids. This model gives valuable information about the size of the geothermal reservoir and location of the magma body beneath this active volcano.
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Carbon to Electrons: A CO2 Circulation Feasibility Study for Sustainable Geothermal Power Generation at the Aquistore CO2 Storage Site	Permanent disposal of captured CO2 from industrial emitters in geologic formations (e.g. deep saline aquifers) is being adopted as a practical step towards net-zero carbon economy. Emerging technologies; such as CO2 Plume Geothermal (CPG); offer an alternative to utilize and cycle the disposed CO2 through subsurface formations to generate sustainable geothermal energy (carbon-to-electrons). The Aquistore site; the largest experimental laboratory in the world for the measurement and monitoring of industrial-scale levels of injected CO2; provides a unique opportunity towards CPG commercialization and to improve its technology readiness level through a pilot field experiment. This work summarizes some of the issues when geologically sequestered CO2 is recirculated to the surface using a well doublet system. It identifies the upside/downside risks of running a CO2 circulation test and provides an assessment of key reservoir variables that potentially affect the CPG performance.
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Specific Surface Free Energy of Ice and Clathrate Hydrates	Clathrate hydrates are compound in which guest molecules being trapped in cages formed by water molecules. It has promising applications in gas storage; gas separation and so on. But its formation should be inhibited in pipelines considering flow assurance. Therefore; its formation kinetics is of vital importance. This abstract compared the specific surface free energy of ice to that of THF (Tetrahydrofuran) hydrate at 4℃ using the Zisman plot
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Nobuo Maeda; nobuo@ualberta.ca; Faculty of Engineering	method. Flat THF hydrate and ice surfaces were prepared. Several halobenzene; fluorocarbon and hydrocarbon liquids were used as the testing liquids. The contact angle (θ) of the testing liquids on THF hydrate and ice surfaces and the surface tension of testing liquids were measured at 4°C. From this information; a Zisman plot was established and the critical surface tension deduced. The results show that THF hydrate had a slightly smaller critical surface tension than that of ice.
Adsorption kinetics and modeling for removal of heavy metals from wastewater by keratin derived sorbents **Zahara, Irum** **izahara@ualberta.ca** 1) Muhammad Arshad; arshad4@ualberta.ca; Agricultural; Life and Environmental Sciences.; 2) M. Anne Naeth;anaeth@ualberta.ca; Agricultural; Life and Environmental Sciences.; 3) Tariq Siddique; tariqs@ualberta.ca; Agricultural; Life and Environmental Sciences.; 4) Aman Ullah;ullah2@ualberta.ca; Agricultural; Life and Environmental Sciences.	Developed keratin biopolymers (KBPs) showed great effectiveness for the removal of metals from synthetic wastewater. Here; we describe sorption behaviour of KBPs and optimization of process parameters such as pH; contact time and temperature. The results revealed that pH change (5.5 and 8.5) had no significant influence on adsorption of metals. However; KBPs achieved maximum adsorption of metals within one hour of equilibrium. These KBPs were further characterized for their adsorption behaviour by constructing adsorption isotherms for metals (Ni; Co; Cd; Cr & As). The results indicated that KBPs exhibited adsorption behaviour for (Ni; Co; Cd; Cr) best described by Langmuir; whereas retention of (As) was best described by Freundlich model. The Langmuir model suggests that adsorption occurs due to the formation of monolayer of atoms at homogenously distributed active sites; whereas Freundlich model demonstrates the adsorption in heterogenous systems.
Composition and Optimal Sampling Time for Soil Invertebrates in Reclaimed Coal Mine Sites In Central Alberta **Chute-Ibsen, Stephanie** **sibsen@ualberta.ca** Dr. M Anne Naeth; anaeth@ualberta.ca; ALES	Land reclamation criteria focus on soil and vegetation. Soil invertebrates are directly linked to ecosystem health; function and stability; and may indicate reclamation success. We compared invertebrates in reclaimed coal mine and reference sites. Invertebrate density in litter and soil was significantly higher in reference than reclaimed sites. Oribatid and Prostigmatid mites and Collembolans were most abundant; each a third of total individuals. In all sites; invertebrate density was significantly higher in soil than litter; Oribatid and Collembolan abundance was positively correlated with litter weight. In reclaimed sites; some invertebrate groups were negatively correlated with soil weight; reflecting low soil pore space. Invertebrate abundance differed significantly with sampling month; optimal timing for individual groups was inconsistent. Oribatid mites and Collembolans have potential as measures of reclamation success; sampling should be conducted late in the growing season.
Sliver/Tannic acid/Fe3+ functionalized magnetic graphene oxide nanocomposite as ultra-efficient catalyst and disinfectant for wastewater treatment **Yang, Wenshuai** **wenshuai@ualberta.ca**	Silver nanoparticles (Ag NPs) have been widely applied as catalysts and disinfectants for wastewater treatment. However; most reported Ag NP-based nanocomposites with a low loading of Ag NPs require a high dosage to achieve satisfactory performance in water treatment process. Herein; we synthesize a novel Ag NPs nanocomposite with an extremely-high loading of Ag NPs (up to 30 wt.%) via tannic acid (TA)/Fe3+ complexation by using magnetic graphene oxide (MGO).). The Ag@MGO-TA/Fe3+ catalyst shows an ultrahigh catalytic reduction of a variety of organic dyes at an extremely low dosage (i.e.; 0.05 mg/mL). In addition; as-prepared Ag@MGO-TA/Fe3+ nanocomposites exhibit disinfection performance against Escherichia coli (E. coli) with ~100% killing efficacy at a very low dosage (i.e.; 20 μg/mL). Moreover; the magnetic Ag@MGO-TA/Fe3+ nanocomposites can be easily recycled by using a magnetic bar. This work provides new insights into design of advanced nanomaterials in water treatment.

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Combinative chemical analysis by functional surface nanodroplets	Surface nanodroplets containing functional components in many fields. In this work; we formed aqueous surface nanodroplet containing pH indicators via the solvent exchange method. The droplets have a long lifetime on a surface and enable a combination of nanoextraction and colorimetric reaction inside of the droplets. We choose organic acids and their mixtures as the model analysts. The acid is extracted from the oil phase into the droplets and then reacts with pH indicator. The extraction and reaction process can be evaluated by the time scale of the color change. The color change of the droplets makes it possible to distinguish the acid mixtures even at the same pH value. As a demonstration; we applied the functional nanodroplets in determining counterfeit alcoholic beverages from diverse spirits. Our approach may also be valuable for chemical analysis in the oil industry; food products and water quality monitoring.
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Life Cycle Analysis of Novel Constructed Wetlands Water Reclamation Materials	Oil sands process water is produced in large quantities in Alberta and must be treated for hard-to-remove pollutants; like heavy metals and naphthenic acids. To address this; FES researchers are developing novel remediation materials to install in constructed wetlands. Our project's purpose is to compare these novel materials using Life Cycle Analysis; a system of accounting for inputs and outputs for all steps in a material's manufacturing; transportation and installation processes; to determine which will have the optimal environmental; economic and social effects. While most LCAs evaluate products that are already in use; we look at potentially commercializable materials ex ante. Our next step is to compare the materials in a pitch-style experiment. We will use our LCA results to pitch each material to venture capitalists; with the pitch having either an environmental or economic focus. Our goal is to identify which material is more able to attract the funds needed to commercialize.
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Water-use implications of low-carbon pathways in the oil sands	While many strategies to mitigate GHG emissions from oil sands production have been proposed; associated water-use impacts of these strategies have not been assessed to a comparable degree; despite the crucial nexus between energy and water in this sector. This research builds on a data-intensive model of oil and gas production in Canada. We evaluate alternative low-carbon oil sands energy supply pathways such as cogeneration; carbon capture-utilization-storage; nuclear; biomass; geothermal; wind; and solar. Key results for each pathway include the GHG abatement cost; cost of saved water; and the water cost of abated GHG compared to baseline.
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Building Futures: Indigenous-Owned Renewable Energy in Alberta and a Just Transition	Transitions towards renewable energy at all scales are urgently needed to meet targets for climate action and renewable electricity generation. Indigenous-led energy transitions are emerging amidst growing acknowledgement of the role of the conventional energy sector in harms to landscapes and communities; and calls for a transition centred around justice and equity. Indigenous communities across Canada are investing in community-led renewable energy projects and energy efficiency measures that centre community members as project planners; managers; owners; and beneficiaries. This research shares
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	the findings of interviews with key informants in the field of Indigenous clean energy and of a community-based participatory research partnership with members of Enoch Cree Nation; Maskêkosihk; where we explore how members imagine community-level energy transitions and the role for the community in the province's emerging clean energy economy.
Renewables	
Synthetic and structural insights into group 14 materials using solid-state NMR	Fueled by population growth and economic development; global energy demands continue to increase. Renewable energy sources will be a vital component of society's efforts to meet and sustain the energy needs of future generations. Silicon has long been the gold-standard material for photovoltaic devices; with photoconversion efficiencies surpassing 25% for single-crystalline solar cells. Much effort has been devoted toward increasing these efficiencies (through band gap engineering; doping; etc.). Another approach for improving upon the performance of photovoltaic devices involves the exploration and development of new materials. Bulk and nanoscale materials based on Group 14 elements have garnered much attention in this regard and have shown favourable (as well as tunable) optoelectronic properties. Here we present our recent results related to the development of Group 14 bulk and nanomaterials; from synthesis to structure using solid-state NMR spectroscopy.
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Crystal facet engineering of 1D metal oxide photocatalysts using chemisorption of divalent cations	We previously found that cathodic treatments of anodic TiO2 nanotube arrays in zinc sulfate electrolytes followed by thermal annealing produced a pronounced <002> crystallographic texture with exposed {110} crystal facets on the lateral faces of the anatase-phase nanotubes. Crystal facet engineering is a powerful tool to enhance photocatalytic reaction rates since the values of the work function; reaction site density; reactant adsorption energy; etc are crystal plane-dependent. Chemisorbed Zn2+ ions on TiO2 surfaces act as a template to direct the orientation and texture of the nanotubes during the subsequent crystallization anneal. This presentation will showcase our work generalizing this treatment to other morphologies and crystal phases (nanorods; rutile); and other divalent ions such as Sr2+; Ca2+; Mg2+; etc. Chemisorption of Sr2+ ions on TiO2 nanotubes promoted the formation of SrTiO3; which is itself a catalytically active semiconductor with properties distinct from TiO2.
Vrushabendrakumar, Damini **vrushabe@ualberta.ca**	
Saralyn Riddell; sriddell@ualberta.ca; Faculty of Engineering; Karthik Shankar; kshankar@ualberta.ca; Faculty of Engineering	
Predicting Noncentrosymmetric Quaternary Tellurides Using Machine Learning	Chalcogenides whose crystal structures do not have a center of inversion have many technological applications as piezoelectric; pyroelectric; and nonlinear optical materials. However; only a small fraction of known chalcogenides are noncentrosymmetric. Searching for new noncentrosymmetric chalcogenides involves trial and error experimentation; as well as "chemical intuition." By identifying patterns and relationships in large datasets; machine learning has been previously used to classify structures of binary (AB) and ternary (ABC; AB2C) intermetallic compounds. Here; we utilize machine learning classifiers to predict noncentrosymmetric structures of quaternary tellurides. The trained Gradient Boosting Classifier (GBC) predicts these structures with an accuracy of 91%. This model was then used to screen 180;000 compositions; a selection of which can be validated experimentally.
Selvaratnam, Balaranjan **balaranj@ualberta.ca**	
Anton Oliynyk; oliynyk@ualberta.ca; Department of Chemistry; Manhattan College; Riverdale; NY 10471; USA; Lawrence Adutwum; adutwum@ualberta.ca; Department of Chemistry; University of Alberta; Edmonton; AB T6G 2R4; Canada; Arthur Mar; amar@ualberta.ca; Department of Chemistry; University of Alberta; Edmonton; AB T6G 2R4; Canada	

More Than Hot Air: A 100-Watt Low Temperature Difference Stirling Engine Prototype for Model Validation	Low temperature heat (< 150°C) is a significant sustainable energy resource that is widely available from industrial waste heat and geothermal sources. Currently this is not being exploited because of its poor exergy (available energy). Low Temperature Difference Stirling Engines (LTDSE) are investigated as a technology for utilizing heat from these sources. A numerical model has been developed accounting for the specific flow dynamics in LTDSE to predict their performance. To experimentally validate this model; a large-scale prototype (power ~100W) is being developed with insight gained from the testing of smaller prototypes. This facility will provide data from a wide range of engine operating conditions; enabled by a design that allows variation of the engine's compression ratio; charge pressure; working gas and heat exchanger modules. Once validated; the model will allow to scale LTDSE technology in size and assess its viability as an economical source of sustainable energy.
Lottmann, Matthias lottmann@ualberta.ca	
David Nobes; dnobes@ualberta.ca; Engineering	
High-Performance Thin Film Composite (TFC) membranes for Energy Harvesting using Pressure Retarded Osmosis (PRO)	Membrane technology has recently shown great potential for the sustainable production of clean energy. Pressure retarded osmosis (PRO); known as 'Blue Energy'; is a membrane-based process that generates power by harnessing osmotic power or salinity gradient energy. In this project; we fabricate thin-film composite PRO membranes which typically consist of at least two layers; a top selective layer; and a bottom porous sublayer. The morphology and mechanical properties of the porous support layer are found to affect the performance of the PRO process significantly. This project aims to design more effective membrane substrates by optimizing their properties to achieve a high power density during the PRO process. In the first phase of the project; we developed a PRO setup that is used for systematically evaluating the membrane performance. This bench-scale setup was designed to achieve high power production at elevated hydraulic pressures for PRO; which is required in real applications.
Aghapour Aktij, Sadegh aghapour@ualberta.ca	
Masoud Rastgar; rastgarf@ualberta.ca; Faculty of Engineering; Mohtada Sadrzadeh; sadrzade@ualberta.ca; Faculty of Engineering; João B.P. Soares; jsoares@ualberta.ca; Faculty of Engineering	
Scale up study on pipeline hydro-transportation of agricultural and forestry residues	The quandary of continuous operation and technology upscaling of biomass-based conversion facilities due to the high cost of transporting feedstock has effectuated research in the field of hydro-transportation of biomass slurries. At present; there is no well-established and validated method for scaling-up pressure-drop data for biomass slurries obtained from smaller pipe diameters to larger pipe diameters. This study seeks to address this issue by designing and commissioning a 4-inch biomass slurry pipeline system and then conducting experiments to establish the relationship between flow parameters and slurry pressure drop. The study will further compare the results obtained from the 4-inch pipeline system with already established results from a 2-inch pipeline system. This will enable better prediction of slurry pressure losses at larger scales and thereby ease the economics of integrating biomass slurry pipeline technology with technologies like hydrothermal liquefaction.
Mohan, Omex omex@ualberta.ca	
Vinoj Kurian; vinoj@ualberta.ca; Engineering; Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	
A semi-supervised GAN method for RUL prediction using failure and suspension histories	Currently; the operation and maintenance (O&M) costs constitute a substantial part of the total life-cycle cost of wind turbines. The O&M costs of a wind project account for about 15–30% of the overall energy generation cost. Accurate prognostic information enables asset managers to formulate optimal O&M planning. Deep learning methods have shown great potential for prognostics in wind turbines. However; deep learning models are strongly dependent on a large number of failure histories. In practice; engineering assets are generally replaced by a new one before failures during planned maintenance and thus a small number of failure histories and more than twice as many suspension histories can often be collected. This work provides a semi-supervised regression method to consider both failure and suspension histories for RUL predictions based on the generative
He, Rui rhe5@ualberta.ca	
Zhigang Tian; ztian@ualberta.ca; Department of Mechanical Engineering.; Ming J. Zuo; ming.zuo@ualberta.ca; Department of	

Mechanical Engineering.	adversarial network. The proposed approach is validated by the case studies.
Improving fault diagnosis performance of deep learning models for wind turbines via speed normalization of vibration signals **Rao, Meng** **mrao@ualberta.ca** Ming J. Zuo	Wind turbines (WTs) are widely used across Canada to generate renewable energy. Early fault diagnosis is critical to assure the reliability of WTs. Reported deep learning models for WT fault diagnosis such as residual network often assume that the rotating speed is constant. In real cases; WTs often work under varying speed conditions; and consequently; reported models are not as effective. To suppress the effects of speed; this work proposes a simple but efficient method to normalize the vibration signal. We propose to divide the vibration signal by a certain power of the speed signals. The optimal power order is selected by minimizing the absolute correlation coefficient between vibration signals and speed signals. The speed normalized vibration signals are then processed by reported deep learning models. Results over two experiment datasets show that using the speed normalized vibration significantly improves the fault diagnosis performance of existing deep learning models for WTs.
Compare Impact of Maximum Power Point Tracking methods of Wind Farms on Turbine Bearings **Nayanasiri, Millawithanachchige Dulika** **nayanasi@ulaberta.ca** Yunwei Li; yunwei.li@ualberta.ca; Engineering; Brendan Calef; calef@ualberta.ca; Engineering	Market penetration of wind energy conversion systems can be further increased by reducing its energy payback time. To this end; the reliability of wind farms should be high. Also; wind turbines should be operated at their optimum point to harvest maximum power. In the conventional approach; each wind turbine is operated at its MPP. However; it gives rise to wake in the wind stream because of the complex interaction with rotor blades. Hence; energy extraction of the downwind turbines is impacted. Therefore; maximum power point tracking methods based on the entire wind farm has gained popularity to increase the overall energy harvest. In this study; the impact of the maximum power point tracking strategies on the lifetime of the main bearing is investigated. To this end; SCADA system data sets of meteorological tower and turbines are employed. Bearing damage is obtained using models and compared to evaluate the effectiveness of each MPP strategy in terms of the power and energy yield.
Energy Storage	
Atomic Layer Deposition of Transition Metal Oxide Catalysts for Zinc-Air Batteries **Labbe, Matthew** **labbe@ualberta.ca**	Cost-effective energy storage is necessary to integrate renewable energy into the power grid. Zinc-air batteries are a promising and low-cost energy storage option; with superior safety and energy density as compared to Li-ion batteries. However; slow reaction rates at the air electrode limit practical power output. Catalysts are thus employed at the air electrode to overcome this limitation and improve the energy efficiency. While conventional catalysts utilize expensive precious metals such as platinum and ruthenium; research into catalysts constructed from more abundant and inexpensive materials will improve the accessibility of zinc-air technology. This work explores transition metal oxides; in particular manganese and iron oxide; as low-cost catalysts for zinc-air batteries. The catalyst layers are created through atomic layer deposition; which is able to conformally coat the surface and porosity of the air electrode to improve battery performance.
Hollow Mesoporous Carbon Nanospheres Decorated with Metal Oxide Nanoparticles as Efficient Earth-Abundant Zinc-Air Battery Catalysts **He, Yingjie** **yingjie3@ualberta.ca**	Hybrids comprising hollow mesoporous nitrogen-doped carbon (HMC) nanospheres and metal-oxide nanoparticles were prepared through a hydrothermal synthesis. These materials exhibit excellent bifunctional catalytic activity in the oxygen reduction and evolution reactions that are core to the efficient operation of Zn-air batteries. When incorporated into prototype devices; Co3O4 and MnCo2O4 nanoparticle-decorated HMC exhibited discharge potentials of 1.26 and 1.28 V at 10 mA cm-2; respectively. 'CoFeNiO'-decorated HMC exhibited a charging potential of 1.96 V at 10 mA cm-2. These metrics are far superior to benchmark Pt-Ru; which displayed discharge and charging potentials of 1.25 and 2.01 V; respectively; at the same current density. The battery equipped with Co3O4-decorated HMC demonstrated 63% initial efficiency before cycling. After cycling at 10 mA cm-2 for 100 hours; the battery efficiency was maintained at 56.5%;

Drew Aasen; daasen@ualberta.ca; Engineering; Alexandra McDougall; atmcdoug@ualberta.ca; Engineering; Haoyang Yu; atmcdoug@ualberta.ca; Science; Matthew Labbe; labbe@ualberta.ca; Engineering; Chuyi Ni; cn2@ualberta.ca; Science; Sarah Milliken; smillike@ualberta.ca; Science; Douglas G. Ivey; divey@ualberta.ca; Engineering; Jonathan G. C. Veinot; jveinot@ualberta.ca; Science	outperforming Pt-Ru (50.2% after 50 h).
Sustainable High Energy Batteries: Electrochemical Grafting and In-Situ Analysis of Organic Cathode Materials **Kissoon, Nicholas kissoon@ualberta.ca** Lingzi Sang; lsang@ualberta.ca; Department of Chemistry; (PI/Supervisor)	Organic cathode materials (OCMs) offer a green and sustainable alternative to traditional transition metal-based materials for the next generation of lithium (Li) ion batteries. Mainly hampered by their solubility in organic liquid electrolytes; OCMs lack the cycling stability needed to progress the materials to commercial applications. Research has largely focused on material designs and cathode architectures that reduce the loss of active material and improve key performance characteristics. This presentation will highlight our investigation of the performance of electrochemically grafted OCMs (e.g. anthraquinone); intended to reduce capacity loss resulting from cycling. Additionally; the conversion-type mechanism for Li storage in OCMs is not well understood. The results from a preliminary investigation into an in-situ vibrational spectroscopy based methodology; providing insight into the conversion-type mechanism for Li storage; will also be presented.
Reduction of all-solid battery decomposition with protective carbon layer **Mah, Justin mah@ualberta.ca**	This research investigates all-solid thiophosphate batteries which have proven to be promising areas for all-solid batteries. However; preliminary results have shown these solid electrolytes to be incompatible with electrode interfaces as solid-electrolyte decomposes into non-ionic conductive by-products at the electrode interface. This in turn reduces the amount of active material in the battery and therefore shortens its lifespan. The first part of this project will apply various potentials to a solid-electrolyte cell to determine the stability window of the solid electrolyte. While this is happening real-time in-situ Raman spectroscopy will be done to characterize molecular changes to the solid electrolyte and characterize the onset of decomposition. The second part of this project will attempt to reduce decomposition by introducing a carbon interlayer between the solid electrolyte and electrode thus preventing direct contact between the solid electrolyte and electrode.
Electrolyte Design in Li-S battery with anti-reductive solvent shell **Nan, Yiling ynan@ualberta.ca** Yiling Nan − School of Mining and Petroleum Engineering; Department of Civil and Environmental Engineering; University of Alberta; Edmonton; Alberta T6G 1H9; Canada ; Zhehui Jin* − School of Mining and Petroleum Engineering; Department of Civil and Environmental Engineering; University of Alberta; Edmonton; Alberta T6G 1H9;	Demand for energy storage systems with high specific energy and durability gradually increases. Though the Lithium-sulfur (Li-S) batteries emerge as a promising energy storage system due to high specific energy and low material cost; their practical applications have been hindered due to their low lifespan. It is known that the parasitic reactions between Li anode and soluble polysulfides (PSs) are the main cause of such a short lifespan. Herein; we report a promising approach to improving Li-S batteries' lifespan: by introducing anti-reductive solvent shells to protect the PS from parasitic reaction with Li anode. We find that the introduction of isopropyl ether (DIPE) as a cosolvent; having high reaction resistance against Li and low solvating power to the PS; can significantly increase the lifespan of the Li-S battery. Both nuclear magnetic resonance (NMR) and molecular dynamics (MD) simulations proved that the DIPE molecules can distribute at the outer shell of PSs as designed.

Canada; Email: zhehui2@ualberta.ca	
Optimizing Silicon Surface-Binder Interactions for Long Life Lithium-ion Batteries **Woodard, Jasper** **jwoodard@ualberta.ca** Peter Kalisvaart; pkalisva@ualberta.ca; Science; Sayed Nagy; synagy@ualberta.ca; Science; Jillian Buriak; jburiak@ualberta.ca; Science	Silicon is a promising anode for lithium-ion batteries (LIBs) since they could increase the capacity of LIB anodes by almost an order of magnitude. Commercialization of silicon anodes is; however; hindered by rapid degradation due to expansion and contraction upon cycling that leads to fracturing and electrolyte breakdown.(1) Mitigating these effects requires a detailed understanding of the interactions between silicon surfaces and binders that serve as the conductive glue holding the silicon together to maintain electrical contact. Here we systematically examine the relationship between binders and surface coatings on silicon nanoparticles in LIBs. We apply precise surface chemistry to control the surface characteristics via hydrosilylation that results in covalently bonded molecular layers on the silicon. In conjunction with commercial polar and nonpolar binders; we investigate the subtle interactions between these important variables. Grey; C.P.; Hall; D.S. Nat. Comm. 2020; 11; 6279.
Flywheel Energy Storage Systems for Electric Vehicle Charging Applications **Sarkar, Soumitra (Sam)** **soumitra@ualberta.ca**	Implementing electric mobility is a pivotal step in Canada's goal to achieve net-zero emissions by 2050. Current electric vehicle (EV) trends and future growth projections indicate the need for increased; robust charging networks. However; consequential electric grid challenges may emerge due to the rise in charging power of fast chargers and the high utilization of public charging infrastructure. High-power demand from the electric grid can lead to intense peak loading and grid instability. To address these issues the integration of flywheel energy storage systems (FESS) within fast-charging stations is considered. By acting as an energy storage buffer; high power can be provided to mitigate grid loads. FESS are recyclable and modular; and offer high charge/discharge cycle life; bi-directional power transfer ability; an accurately known state of charge; which makes them a feasible candidate. Academic research and commercial development effort are currently ongoing internationally.
Using pore former in the anode catalyst layer to increase the performance of the proton exchange membrane water electrolyzer **Mandal, Manas Kumar** **manas@ualberta.ca**	Polymer electrolyte membrane water electrolyzers (PEMWE) can be used to store GWh of renewable electrical energy in the form of hydrogen. Its performance is significantly affected by the catalyst layer (CL) microstructure which is influenced by the catalyst ink composition and the fabrication process. Due to the use of an unsupported catalyst (IrO2) in PEMWE; the porosity of the CL is low resulting in a low CL surface area and high activation losses. By increasing the porosity; it is hypothesized that more catalyst surface area will be exposed to the reactant and electrolyte. CL porosity can be increased by using a pore former; a sacrificial material. In this study; the pore former was removed from the CL to study the effect of the CL porosity on the CL thickness; electrochemical surface area (ECSA); and performance. An improvement in the cell performance is observed which can be ascribed to an increased ECSA due to the use of the pore former.
Artificial Photosynthesis with a Ruthenium-Rhenium Assembly for Solar CO2 Reduction **Martinez Perez, Octavio** **martnezp@ualberta.ca** Steven Bergens; sbergens@ualberta.ca	The conversion of sunlight and carbon dioxide into chemical fuels is a necessary solution for global warming mitigation by solar energy utilization. Solar fuels can be utilized in large-scale energy generation; long-range transportation (especially by air) without net increases of atmospheric CO2. Solar fuels also store vast amounts of solar energy. The research in our lab involves the synthesis and performance evaluation of a chromophore-catalyst assembly [Ru-Re] for the reduction of CO2 under homogeneous and heterogeneous conditions powered by sunlight. Preliminary photochemical results prove CO being the main product for CO2 reduction and photoelectrochemical results generate up to -20 µA/cm2 corresponding to the CO2 reduction on an ITO surface at -0.5 V vs Ag/AgO in CO2 saturated 0.1M LiClO4 acetonitrile.
Systems and Futures	

Robots; machine learning; and self-run labs. The coming era of scientific discovery	While we focus our discussions on the transition to a low-carbon world; another transition is gaining speed: automated self-run; and auto-decisioning experimentation. Presently; most experimental work in energy materials (e.g. solar semiconductors; catalysts; battery electrodes; etc.) relies on multidimensional; time-consuming; repetitive; and very delicate processes at the bench manually performed by human researchers. Robotic and modular all-in-one systems are becoming automated assistants capable of efficiently exploring or exploiting a larger segment of the parameter space and of making informed next-steps optimization decisions. Thus; the human scientist is free to spend more time thinking and expanding their creative potential based on their experimental data interpretations even before analytical models are proposed. This work highlights premier examples of self-run labs and machine learning-assisted experimentation applied to energy materials research.
Velazquez Osorio, Adrian avelazqu@ualberta.ca	
Jillian M. Buriak; jburiak@ulberta.ca; science	
Two-Stage Stochastic Optimization of a Virtual Power Plant	We present a revenue maximization strategy for a prosumer who owns and operates a solar farm and an Electric Vehicle (EV) charging station supporting vehicle-to-grid technology. The prosumer places energy bids a day in advance; to the day-ahead market. On the delivery day; a deficit in solar generation is likely due to the stochastic nature of solar power. The prosumer leverages the EVs' flexible charging schedule and trades energy in the imbalance market; mitigating the solar generation deficit. In addition; it ensures EVs are charged to their desired state-of-charge before departure. Considering the uncertainty of market prices; renewable generation; mobility; and demand of EVs; maximizing the revenue over a time horizon is a difficult task. In this work; we propose online and offline algorithms for maximizing revenue in the two markets while satisfying the demand of EVs. The offline algorithm solves an optimization problem under an oracle with perfect knowledge of the future.
Rahman, Saidur saidur@ualberta.ca	
Omid Ardakanian; oardakan@ualberta.ca; Faculty of Science	
Modelling Regional Hydropower Development with GCAM-Canada	Climate action plans for Canada often call for electrification as a method to reduce emissions; which would require significant electricity generation expansion. We are developing the Global Change Analysis Model-Canada; which can be used to simulate and compare alternative future energy pathways; while accounting for integrated system components including economics; land use; and environment. Recent model developments enable a detailed spatial representation of Canadian hydropower resources for simulation of future hydropower growth; while accounting for integrated energy system components. We will present a model scenario analysis to compare climate policy alternatives; including carbon prices; to 2050 to assess the role of hydropower on a spatially-refined basis in alternative future energy systems. Benefits and trade-offs regarding future electricity generation and hydropower investments; emissions reduction strategies; and fuel switching will be discussed.
Arbuckle, Evan ejarbuck@ualberta.ca	
Evan Davies; edavies1@ualberta.ca; Faculty of Engineering; Diego Chiappori; chiappor@ualberta.ca; Faculty of Engineering	
A Numerical Study on Energy Extraction from Retrofitted Co-axial Wells	Oil wells at the end of their production life have the potential to be retrofitted to exploit any available geothermal energy resource; avoiding the expense of high drilling costs. Two-phase fluid flow and heat transfer models are required for predicting the system and possible energy production. We have developed a numerical model where the phase equilibrium calculations for CO2-; and air-water systems are coupled with continuity; energy and momentum equations. Inclusion of the two-phase flow within the model allows investigation of the design of a hydraulic air compressor within the retrofitted co-axial well. This device draws ambient air into the well; compresses and heats the fluid on transit through the well producing high pressure air and heat. This research will investigate the design space and optimum conditions for retrofitted wells.
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Jonathan Banks; email: jbanks@ualberta.ca; Faculty:Department of Earth and Atmospheric Sciences; David S. Nobes; email:dnobes@ualberta.ca; Faculty:Department of Mechanical Engineering	

Graph-theory-inspired unified relationships in power converters **Li, Yuzhuo** **yuzhuo@ualberta.ca** Yunwei (Ryan) Li; yunwei.li@ualberta.ca; Engineering	Renewable energy becomes a promising “Panacea” for the vista of a low-carbon; clean and sustainable society. It is preferably regulated through power electronics converters and actively combined with storage to blend in the modern power grid or supply local customers. Driven by such a “green economy” outlook; power converters gain great development. As the research volume increases fast; resemble converter circuits and operation methods are emerging; calling for systematic studying tools. In this talk; important graph theories are introduced as such tools for power converters. Duality and especially the emerging isomorphism theory provides different innovation perspectives and promising potentials that can help people find suitable converters topologies as well as operation methods; e.g. new converters with better power quality; new modulation with better loss distribution; systematic fault-tolerant strategy for higher reliability; etc.
Production of renewable biojet fuels **Bakhtiari Ziabari, Fatemeh** **fbakhtia@ualberta.ca**	According to the International Renewable Energy Agency, if the aviation sector were a country, it would be the eight largest emitter of greenhouse gases globally. Thus, lowering the greenhouse gas emissions of the aviation sector has become an important factor to mitigate the effects of climate change. Lipid to hydrocarbon technology (LTH) is a novel technology that can convert a variety of lipid feedstocks into various chemicals and solvents, as well as gasoline and diesel fuels. LTH can be used to convert waste oils and fats to renewable biojet fuels that can be used as an alternative to the current fossil-based fuels. But there is still much work needed to be done to produce the biojet fuel for commercial purposes in a cost-effective manner. The aim of this project is to scale up the biojet production technology from lab-scale to bench-scale in a 1-liter reactor using light reactive gases in order to produce renewable biojet fuel with qualities similar to fossil-based fuels.
Projections of cost of ownership; GHG intensity; and market share of vehicles in the passenger and freight transportation sectors **Haider, Minza** **minza@ualberta.ca** Matthew Davis; mbdavis@ualberta.ca; Engineering; Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	This research looks at the future of transportation in Alberta. Passenger light-duty vehicles (cars); school buses; city buses; intercity buses; light-duty freight; medium-duty freight; and heavy-duty freight sectors are modelled considering the different types of vehicles that will be available; including battery electric and hydrogen fuel cell electric vehicles. The cost of ownership and market share of vehicles within each transportation sector has been projected to 2050. A system-wide GHG intensity comparison of conventional; battery-electric; and hydrogen-fuel cell electric cars and heavy-duty freight vehicles in Alberta has been made. This research indicates that a transformative transition in Alberta’s transportation sector is coming.
Analyzing the spatiotemporal variation of urban heat islands with land use changes: A case of Edmonton; Canada **Welegedara, Nilusha** **yalingas@ualberta.ca** Sandeep Agrawal; sagrawal@ualberta.ca; Faculty of Science; Ghazal Lotfi; lotfi@ualberta.ca; Faculty of Science	Urban heat island (UHI) refers to an area in a city that is much warmer than its rural surroundings. This study explores whether there was a significant change in UHIs across neighbourhoods in the city of Edmonton over the last two decades. We used Landsat satellite images from 2000 to 2020 acquired during summer and winter periods to generate land surface temperatures and land use maps. Results indicate a significant UHI increase within residential neighbourhoods particularly in developing neighbourhoods over the last two decades. The temperature increase in these neighbourhoods was strongly linked to the reduced vegetation and increased built-up areas. We also noticed that in summer; the surface temperature difference in some industrial and residential neighbourhoods within the city showed an increase of 4-90C compared to surrounding rural areas. Outcome of this study will help municipal planners and policy-makers develop heat mitigation and adaptation strategies for neighbourhoods.
What determines municipal renewable energy development? Insights from a mixed-methods	Advancing renewable energy is critical to reducing carbon emissions in Alberta. Among the actors engaged in energy transition are municipalities; who can play key roles in developing renewable projects with local benefits. Employing a mixed-methods approach;

study of municipalities in Alberta	this study seeks to understand the motivations of municipal decision-makers to engage in energy transition. A survey of municipal employees and elected officials in Alberta is analysed to understand the intention to develop renewable projects and the variance of intention across municipal and respondent characteristics. Through document analysis and interviews with municipal employees; councillors; experts; and stakeholders; a case study of the City of Edmonton analyses detailed roles the City does and could have in the energy transition. This research employs the theory of planned behaviour and transition theory; conceptualising decision-making and situating municipal efforts within the landscape of energy transition in Alberta.
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John Parkins; jparkins@ualberta.ca; Faculty of Agriculture; Environment; and Life Sciences	
A decarbonization assessment of Canada's electricity generation sector	This work performs an integrated assessment of the environmental footprints associated with deep decarbonization of the electricity generation sector. Two scenarios were analyzed at the national level; the first scenario was based on current provincial electricity system trajectories and the second was developed with a deep electricity decarbonization target by 2050. A long-term province-wise analysis resulted in the quantification of GHG mitigation; technology mixes; and associated marginal costs of decarbonization. The analysis identified Alberta as a key region for energy transition due to their fossil-intensive electricity sector. A more robust scenario analysis was completed on Alberta where 382 low-carbon scenarios were assessed. The results answer the question: What are the costs of transitioning Alberta’s electricity sector to a low-carbon system?
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Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	

Poster Presentations

High-Performance Thin Film Composite (TFC) membranes for Energy Harvesting using Pressure Retarded Osmosis (PRO)	Membrane technology has recently shown great potential for the sustainable production of clean energy. Pressure retarded osmosis (PRO); known as 'Blue Energy'; is a membrane-based process that generates power by harnessing osmotic power or salinity gradient energy. In this project; we fabricate thin-film composite PRO membranes which typically consist of at least two layers; a top selective layer; and a bottom porous sublayer. The morphology and mechanical properties of the porous support layer are found to affect the performance of the PRO process significantly. This project aims to design more effective membrane substrates by optimizing their properties to achieve a high power density during the PRO process. In the first phase of the project; we developed a PRO setup that is used for systematically evaluating the membrane performance. This bench-scale setup was designed to achieve high power production at elevated hydraulic pressures for PRO; which is required in real applications.
Aghapour Aktij, Sadegh aghapour@ualberta.ca	
Masoud Rastgar; rastgarf@ualberta.ca; Faculty of Engineering; Mohtada Sadrzadeh; sadrzade@ualberta.ca; Faculty of Engineering; João B.P. Soares; jsoares@ualberta.ca; Faculty of Engineering	
Modelling Regional Hydropower Development with GCAM-Canada	Climate action plans for Canada often call for electrification as a method to reduce emissions; which would require significant electricity generation expansion. We are developing the Global Change Analysis Model-Canada; which can be used to simulate and compare alternative future energy pathways; while accounting for integrated system components including economics; land use; and environment. Recent model developments enable a detailed spatial representation of Canadian hydropower resources for simulation of future hydropower growth; while accounting for integrated energy system components. We will present a model scenario analysis to compare climate policy alternatives; including carbon prices; to 2050 to assess the role of hydropower on a spatially-refined basis in alternative future energy systems. Benefits and trade-offs regarding future electricity generation and hydropower investments; emissions reduction strategies; and fuel switching will be discussed.
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Catalytic deoxygenation and Isomerization of Fatty Acid using In-Situ Hydrogen to produce biojet fuel	Renewable jet fuels are seen as one of the primary means by which the commercial aviation industry can reduce their carbon footprint in the near and mid-term. The Bressler group has developed and patented the lipid to hydrocarbon technology capable of converting fats and oils to renewable drop-in hydrocarbon fuels. In this research catalytic isomerization of a model fatty acid was conducted to induce the production of branched hydrocarbons; which are important for the stringent cold flow properties of aviation fuels. Reactions were conducted using commercial catalysts with varying acidity; surface area; etc. in 15 mL stainless steel microreactors at various temperatures; reaction times; and catalyst to feed ratios. Preliminary results show complete deoxygenation and significant isomerization was achieved when compared to control. This research demonstrates potential of generating biojet fuels from the LTH technology without the use of external hydrogen.
Arumugam, Ramesh **rarumuga@ualberta.ca**	
Dr. Justice Asomaning; asomanin@ualberta.ca; Biorefining Conversions and Fermentation Laboratory; Agricultural; Food and Nutritional Science (AFNS); Agricultural Forest Centre; University of Alberta; Edmonton -T6G 2P5; Canada; ; Prof. David C. Bressler; dbressle@ualberta.ca; Biorefining Conversions and Fermentation Laboratory; Agricultural; Food and Nutritional Science (AFNS); Agricultural Forest Centre; University of Alberta; Edmonton -T6G 2P5; Canada	
Production of renewable biojet fuels	According to the International Renewable Energy Agency, if the aviation sector were a country, it would be the eight largest emitter of greenhouse gases globally. Thus, lowering the greenhouse gas emissions of the aviation sector has become an important factor to mitigate the effects of climate change. Lipid to hydrocarbon technology (LTH) is a novel technology that can convert a variety of lipid feedstocks into various chemicals and solvents, as well as gasoline and diesel fuels. LTH can be used to convert waste oils and fats to renewable biojet fuels that can be used as an alternative to the current fossil-based fuels. But there is still much work needed to be done to produce the biojet fuel for commercial purposes in a cost-effective manner. The aim of this project is to scale up the biojet production technology from lab-scale to bench-scale in a 1-liter reactor using light reactive gases in order to produce renewable biojet fuel with qualities similar to fossil-based fuels.
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Using in vitro bioassays to predict the impact of OSPW on receiving aquatic environments	Today; oil sands process water (OSPW) is stored in tailing ponds but efforts are in motion to discharge treated OSPW into regional water bodies. OSPW consists of organics and inorganics; which can cause acute and sub-chronic toxicity to a range of organisms. Hence receiving aquatic environments should be assessed for ecotoxicological impacts before and after the discharge of treated OSPW. A battery of in vitro bioassays has the potential to detect cell toxicity pathways related to chemical pollution. The bioassays will be used to analyze the organic fractions of the aqueous fraction of treated and untreated OSPW; municipal wastewater and OSPW seepage. The chosen toxicity pathways are (1) non-specific toxicity: cytotoxicity; (2) specific toxicity: immunotoxicity; activation of xenobiotic metabolism endpoints and activation of endocrine estrogen receptor; and (3) reactive modes of action: genotoxicity; mutagenicity and oxidative stress. Currently; preliminary results are being analyzed.
Barrow, Kia **barrow1@ualberta.ca**	
Proton Exchange Membrane Water Electrolysis using Low Loading of Iridium Alloy	Hydrogen can be produced through water electrolysis with electricity from renewable energy making it a viable green alternative to fossil fuels. Catalysts used for water splitting are primarily made of iridium but are expensive; so alternatives that use less material are needed to become more commercially feasible. For this project we will use iridium alloy

Catalysts by Inkjet Printing	catalysts; IrNi and IrCu; which use less iridium by replacing some of it with the other metal. Small-scale tests have shown better activity than pure iridium due to the interaction between the metals. The catalysts will be deposited on the membrane using inkjet printing which has the benefits of precise control of deposition and can create low catalyst loading by forming very thin layers usually 3-5 µm. The performance of the catalyst coated membranes will be directly compared to state-of-the-art systems by evaluation in a proton exchange membrane electrolysis cell by measuring hydrogen production efficiency and cell durability.
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Marc Secanell; secanell@ualberta.ca; Engineering; Steven Bergens; steve.bergens@ualberta.ca; Science	
Exploring biomass and heavy oil co-processing enabled by copper catalysis	Biomass valorization and green hydrogen production are two key planks in the ongoing transition to a low-carbon economy. We have designed a novel heterogeneous copper catalyst that seamlessly straddles these two research areas; harvesting hydrogen from internal hydroxyl residues in biomass and using that hydrogen to drive the depolymerization of lignin into monocyclic aromatic compounds. This internal transfer hydrogenolysis proceeds under remarkably mild conditions; and completely avoids the use of hydrogen generated from traditional fossil fuel sources. Critically; this 'hydrogen harvesting' strategy can be coupled with reductive processing of polycyclic aromatic molecules found in heavy oil; creating potential opportunities for co-processing of biomass and heavy oil into commodity petrochemicals and transportation fuels.
Brown, Orain orain@ualberta.ca	
Jeffrey M. Stryker; Department of Chemistry; Faculty of Science; University of Alberta	
Life Cycle Analysis of Novel Constructed Wetlands Water Reclamation Materials	Oil sands process water is produced in large quantities in Alberta and must be treated for hard-to-remove pollutants; like heavy metals and naphthenic acids. To address this; FES researchers are developing novel remediation materials to install in constructed wetlands. Our project's purpose is to compare these novel materials using Life Cycle Analysis; a system of accounting for inputs and outputs for all steps in a material's manufacturing; transportation and installation processes; to determine which will have the optimal environmental; economic and social effects. While most LCAs evaluate products that are already in use; we look at potentially commercializable materials ex ante. Our next step is to compare the materials in a pitch-style experiment. We will use our LCA results to pitch each material to venture capitalists; with the pitch having either an environmental or economic focus. Our goal is to identify which material is more able to attract the funds needed to commercialize.
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Matthew Kingston; mwk3@ualberta.ca; Alberta School of Business; Dev Jennings; dj1@ualberta.ca; Alberta School of Business	
High performance photoelectrochemical water-splitting through harvesting of plasmonic hot holes	I designed; fabricated; characterized and tested ternary heterojunctions consisting of carbon nitride quantum dots; TiO2 nanotubes and embedded plasmonic nanoparticles. The ternary heterojunction showed high performance in water-splitting generating >2.5 mA/cm2 of photocurrent density under AM1.5G solar illumination (100 mW/cm2) with Faradaic efficiencies approaching 80% at 0.6 V bias vs Ag/AgCl. Clear evidence of the role of visible photons in driving the photoelectrochemical reaction was obtained. High quantum yields were obtained for blue photons. Most plasmonic hot carrier devices have focused on the extraction of hot electrons. The ternary heterojunctions function as photoanodes and split water by efficiently harvesting hot holes. This; in turn; allows carrier thermalization losses to be minimized; enabling high absolute quantum yields.
Chaulagain, Narendra nchaulag@ualberta.ca	
Sachin Kadian; skadian@ualberta.ca; Faculty of Engineering; Ehsan Vahidzadeh; vahidzad@ualberta.ca; Faculty of Engineering; Karthik Shankar; kshankar@ualberta.ca; Faculty of Engineering	
Composition and Optimal Sampling Time for Soil Invertebrates in Reclaimed Coal	Land reclamation criteria focus on soil and vegetation. Soil invertebrates are directly linked to ecosystem health; function and stability; and may indicate reclamation success. We compared invertebrates in reclaimed coal mine and reference sites. Invertebrate density in litter and soil was significantly higher in reference than reclaimed sites. Oribatid and

Mine Sites In Central Alberta	Prostigmatid mites and Collembolans were most abundant; each a third of total individuals. In all sites; invertebrate density was significantly higher in soil than litter; Oribatid and Collembolan abundance was positively correlated with litter weight. In reclaimed sites; some invertebrate groups were negatively correlated with soil weight; reflecting low soil pore space. Invertebrate abundance differed significantly with sampling month; optimal timing for individual groups was inconsistent. Oribatid mites and Collembolans have potential as measures of reclamation success; sampling should be conducted late in the growing season.
Chute-Ibsen, Stephanie sibsen@ualberta.ca	
Dr. M Anne Naeth; anaeth@ualberta.ca; ALES	
Gel Polymer Electrolyte for Zinc-Air Batteries Operating at Low Temperatures	There has been extensive research on zinc-air batteries (ZABs) in recent years; due in part to the improved safety and abundance of zinc relative to lithium in lithium-ion batteries (LIBs). However; ZABs suffer from liquid electrolyte leakage; dendrite formation and shape change of the zinc electrode. The use of gel polymer electrolytes can help reduce these negative effects. Much of Canada is subjected to extremely cold temperatures (less than -30oC) in the winter and like many other batteries; ZAB performance is reduced at low temperatures due to the increase in viscosity and decrease in conductivity of the electrolyte. The aim of this work is to develop a low temperature electrolyte for ZABs through in-situ fabrication. The use of in-situ gelation can lower the contact resistance between the gel polymer electrolyte and the electrodes; which can improve ion transport; reaction kinetics at the air electrode and overall battery performance.
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Douglas G Ivey; divey@ualberta.ca; Faculty of Engineering	
A decarbonization assessment of Canada's electricity generation sector	This work performs an integrated assessment of the environmental footprints associated with deep decarbonization of the electricity generation sector. Two scenarios were analyzed at the national level; the first scenario was based on current provincial electricity system trajectories and the second was developed with a deep electricity decarbonization target by 2050. A long-term province-wise analysis resulted in the quantification of GHG mitigation; technology mixes; and associated marginal costs of decarbonization. The analysis identified Alberta as a key region for energy transition due to their fossil-intensive electricity sector. A more robust scenario analysis was completed on Alberta where 382 low-carbon scenarios were assessed. The results answer the question: What are the costs of transitioning Alberta’s electricity sector to a low-carbon system?
Davis, Matthew mbdavis@ualberta.ca	
Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	
Lowering the Cost of Water Electrolysis with Anion Exchange Membranes and Nickel-based Catalysts	Electrolysis can split water into hydrogen and oxygen gases using electricity; which if generated by renewable sources; has zero-emissions. Hydrogen can then be stored to later use in generating electricity; heating; or powering vehicles. Proton exchange membrane cells allow for a compact design that can be run intermittently from power sources like wind and solar but require expensive platinum and iridium catalysts due to acidic cell conditions; and if usage increases material costs will as well. Using an anion exchange membrane (AEM) instead results in an alkaline cell with similar benefits that can use less expensive nickel catalysts. Further development of AEM cells is required; including on catalyst layer fabrication as it must be a composite of catalyst and ion exchange ionomer to create reaction sites; and be able to operate long-term with minimal losses. To do so; AEM electrolysis cells will be constructed and tested in-situ to study cell performance and durability.
Eitzen, Jasper eitzen@ualberta.ca	
The techno-economic assessment of alternative materials for hydrogen production via photocatalytic water splitting	
Effects of Coal Mining in Alberta on Population Health	Does past coal mining-generated water pollution impose health effects on Albertans living downstream from coal mines? To pursue this question; we are estimating potential impacts of water pollution on lifetime healthcare demand (e.g. annual doctor visits) for infants and youth. Our hypothesis is that residents living downstream from mining activity are exposed to higher levels of water contaminants (e.g. various heavy metals) due to acid mine drainage (AMD). Moreover; as coal mines are predominantly located in rural areas; we consider the possibility of domestic water wells acting as mechanisms of exposure. With upstream residents acting as counterfactuals to residents living downstream from
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Luckert; mluckert@ualberta.ca; Agricultural; Life & Environmental Sciences	the same coal mines; we may isolate local health effects (or lack thereof) arising from past mining activity. As coal mining continues to be an important economic resource for Alberta (e.g. international export); understanding its associated health consequences will aid in responsible coal mining.
Transition to cleaner grid for fossil fuel dominant jurisdictions: Development of a consequential lifecycle assessment approach **Gemechu, Eskinder gemechu@ualberta.ca** Tanveer Hassan Mehedi; tanveerh@ualberta.ca; Engineering; Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	Solar and wind are going to play a major role in the energy transition. However; the long-term environmental and economic consequences of different policy alternatives for renewable and low-carbon energy sources are not straightforward. Understanding them requires a robust analysis from multiple perspectives to provide policy decision-makers science-driven insights. This study focuses on developing a framework to provide insights on the long-term environmental consequences of marginal changes in electricity generation. The province of Alberta has been considered as a case study. An integrated energy generation model was developed to obtain probable future electricity mixes; cost of generation; and GHG emissions; which aids in identifying marginal suppliers. Nine scenarios focusing on energy technologies; and policy initiatives were developed. The results suggest that wind energy will have significant penetration in all scenarios; up to 55% of the electricity mix in 2050.
AI - based engine control methods for advanced combustion engines **Gordon, David dgordon@ualberta.ca** Armin Norouzi; norouziy@ualberta.ca; Engineering; Bob Koch; bob.koch@ualberta.ca; Engineering	Homogenous charge compression ignition (HCCI) internal combustion engines are a promising combustion strategy to reduce greenhouse gas emissions. However, the requirement for a detailed model and tight time constraints required for cycle to cycle control limit how model predictive control (MPC) for a can be applied. One possible solution is the use of artificial intelligence (AI) to solve both challenges. The implementation of AI based models reduces the need for complex physical combustion models and also enables the implementation of adaptive training. The addition of adaptive training allows for the AI based model to adapt to ever changing environmental conditions that affect the combustion process. The MPC can be based on the AI based engine model and can be implemented in real-time on the engine controller. This is possible given the high computation power of modern prototyping engine controllers. However, production engine control units (ECU) are have less computational ability which limits the possibility of MPC implementation on a production engine. This is where AI based imitation of the MPC can be used to simplify the controller implementation.
Manufacture of Porous Transport Layers for Polymer Electrolyte Membrane Electrolysis with Laser Powder Bed Fusion **Gupta, Pranav pranav5@ualberta.ca** Ahmed Jawad Qureshi; ajquresh@ualberta.ca; Faculty of Engineering (Mechanical); Marc Secanell Gallart; secanell@ualberta.ca; Faculty of Engineering (Mechanical)	Polymer Electrolyte Membrane Electrolysis (PEME) is a promising technique for converting electric energy into hydrogen. However; the cost of the precious catalysts; the porous transport layer (PTL) and the operating voltage losses due to poor catalyst utilization and transport losses in the PTL limit its widespread commercialization. For a cheap and efficient PEME; PTLs should be produced at reasonable costs and exhibit graded porosity and transport properties; e.g.; electrical conductivity. With current state-of-the-art manufacturing techniques; however; it is difficult to obtain the desired PTL properties. Laser Powder Bed Fusion (LPBF) allows for the manufacture of complex parts without the design constraints posed by the traditional manufacturing processes. This project aims to manufacture PTLs via LPBF by manipulating laser energy density via laser power and scanning speed during the process to obtain selective PTL porosity characteristics through-thickness.
Steam Explosion and Enzymatic Digestion with Sugar Recovery as Pretreatments for Cellulose Nanocrystals Production	The industrial process to produce bioethanol from lignocellulosic biomass requires an advanced cellulase cocktail to depolymerize the recalcitrant crystalline region of cellulose to fermentable sugars. These enzymatic approaches are often associated with high costs due to the high cost of cellulase cocktails. Therefore; to offset such economic challenges;

Haddis, Dagem **haddis@ualberta.ca** Michael Chae ; mchae@ualberta.ca	biorefinery strategies need to be designed that provide high fermentable sugars recovery with additional high value-added products from lignocellulosic biomass. The crystalline regions of cellulose are precursors for a nanostructured material called cellulose nanocrystals (CNCs); and the amorphous chains can be hydrolyzed to sugars and subsequently fermented to ethanol. In this study; a steam explosion pretreatment combined with enzyme and acid hydrolyses were exploited to co-generate CNCs (at an increased yield) and fermentable sugars from poplar wood chips.
Projections of cost of ownership; GHG intensity; and market share of vehicles in the passenger and freight transportation sectors **Haider, Minza** **minza@ualberta.ca** Matthew Davis; mbdavis@ualberta.ca; Engineering; Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	This research looks at the future of transportation in Alberta. Passenger light-duty vehicles (cars); school buses; city buses; intercity buses; light-duty freight; medium-duty freight; and heavy-duty freight sectors are modelled considering the different types of vehicles that will be available; including battery electric and hydrogen fuel cell electric vehicles. The cost of ownership and market share of vehicles within each transportation sector has been projected to 2050. A system-wide GHG intensity comparison of conventional; battery-electric; and hydrogen-fuel cell electric cars and heavy-duty freight vehicles in Alberta has been made. This research indicates that a transformative transition in Alberta's transportation sector is coming.
Investigating the Effect of Heat Exchanger Volume on Power Output in a Low-Temperature Stirling Engine **Hasanovich, Linda** **lhasanov@ualberta.ca**	Low-temperature difference Stirling engines have a fixed amount of energy available to power the engine. Maximizing the thermal exchange from the heat source to the working gas is critical to increase the power output of the engine. One way to do this is to increase the size of the heat exchangers to improve the heat transfer. However; heat exchangers contribute to the dead volume of the engine. Dead volume is any volume that is not swept by the pistons. It is known that excess dead volume tends to reduce the engine power output by reducing the pressure swing. An optimum heat exchanger volume should exist that maximizes the engine power with improved heat exchange and without excessive dead volume. To investigate this; a third order Stirling engine model is used which captures the phenomenon of heat transfer in the heat exchanger and the effect of dead volume in the Stirling engine. The heat exchanger size is varied to determine the engine power; pressure; and gas temperatures.
Hollow Mesoporous Carbon Nanospheres Decorated with Metal Oxide Nanoparticles as Efficient Earth-Abundant Zinc-Air Battery Catalysts **He, Yingjie** **yingjie3@ualberta.ca** Drew Aasen; daasen@ualberta.ca; Engineering; Alexandra McDougall; atmcdoug@ualberta.ca; Engineering; Haoyang Yu; atmcdoug@ualberta.ca; Science; Matthew Labbe; labbe@ualberta.ca; Engineering; Chuyi Ni; cn2@ualberta.ca; Science; Sarah Milliken; smillike@ualberta.ca; Science; Douglas G. Ivey; divey@ualberta.ca; Engineering; Jonathan G. C. Veinot; jveinot@ualberta.ca; Science	Hybrids comprising hollow mesoporous nitrogen-doped carbon (HMC) nanospheres and metal-oxide nanoparticles were prepared through a hydrothermal synthesis. These materials exhibit excellent bifunctional catalytic activity in the oxygen reduction and evolution reactions that are core to the efficient operation of Zn-air batteries. When incorporated into prototype devices; Co_3O_4 and $MnCo_2O_4$ nanoparticle-decorated HMC exhibited discharge potentials of 1.26 and 1.28 V at 10 mA cm-2; respectively. 'CoFeNiO'-decorated HMC exhibited a charging potential of 1.96 V at 10 mA cm-2. These metrics are far superior to benchmark Pt-Ru; which displayed discharge and charging potentials of 1.25 and 2.01 V; respectively; at the same current density. The battery equipped with Co_3O_4-decorated HMC demonstrated 63% initial efficiency before cycling. After cycling at 10 mA cm-2 for 100 hours; the battery efficiency was maintained at 56.5%; outperforming Pt-Ru (50.2% after 50 h).

Free Shipping? Exploring the Protein Cargo Content of Outer Membrane Vesicles (OMVs) in Methanotrophic Bacteria	The potent greenhouse gas methane; with a global warming potential of ~30 times greater than carbon dioxide; is emitted by various natural and anthropogenic processes. The presence of methane is beneficial to a subset of microorganisms known as methane-oxidizing bacteria; or methanotrophs; which consume methane as a carbon and energy source. In addition; methanotrophs can be exploited for their ability to synthesize value-added products; such as biofuels and bioplastics. For the first time; Outer Membrane Vesicles (OMVs) production has been identified in a methanotroph; Methylomicrobium album BG8. These membrane-enclosed structures can transport biological cargo outside of the bacterium. Purified OMVs were isolated from host cells and mass spectrometry was used to determine their protein content. Insights on the biological cargo can be used to elucidate physiological export mechanisms and devising strategies for the industrialization of methanotrophs.
Hermary, Mariah **hermary@ualberta.ca**	
Synthetic and structural insights into group 14 materials using solid-state NMR	Fueled by population growth and economic development; global energy demands continue to increase. Renewable energy sources will be a vital component of society's efforts to meet and sustain the energy needs of future generations. Silicon has long been the gold-standard material for photovoltaic devices; with photoconversion efficiencies surpassing 25% for single-crystalline solar cells. Much effort has been devoted toward increasing these efficiencies (through band gap engineering; doping; etc.). Another approach for improving upon the performance of photovoltaic devices involves the exploration and development of new materials. Bulk and nanoscale materials based on Group 14 elements have garnered much attention in this regard and have shown favourable (as well as tunable) optoelectronic properties. Here we present our recent results related to the development of Group 14 bulk and nanomaterials; from synthesis to structure using solid-state NMR spectroscopy.
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Chuyi Ni; cn2@ualberta.ca; Science; ; Jonathan G.C. Veinot; jveinot@ualberta.ca; Science; Vladimir K. Michaelis; vmichael@ualberta.ca; Science	
Effect of continuous feeding and pulsed feeding operations in fed-batch fermentation for bioethanol production	Bioethanol is a promising alternative fuel to support the increasing energy demand that comes from the growing global population. However; bioethanol production through fermentation needs further research to improve the overall yield and efficiency. To this end; we applied a fed-batch fermentation approach; in which fresh nutrients were supplied during operation; in an attempt to improve bioethanol production. Firstly; we employed a continuous feeding strategy where glucose was continuously fed into the bioreactor. However; ethanol yield per gram of glucose consumed decreased in this system. Next; we tried a pulsed feeding approach in which glucose was fed into the system when a signaling parameter detected the depletion of glucose in the fermentation broth. In this manner; ethanol yields were improved as compared to the batch mode. The benefits observed from the pulsed feeding operation have the potential to enhance bioethanol production at the industrial scale.
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Michael Chae; mchae@ualberta.ca; Department of Agricultural; Food and Nutrition Science; Dominic Sauvageau; dsauvage@ualberta.ca; Department of Chemical and Materials Engineering; David C. Bressler; dbressle@ualberta.ca; Department of Agricultural; Food and Nutrition Science	
Experimental investigation of heat transfer enhancement in reciprocating flow by the implementation of axial vortex generator	Stirling engines are known as one of the prospective solutions for future energy problems. This engine works based on the heat transfer from a heat source; a hot heat-exchanger (HHEX); to the working fluid and from the same fluid to a heat sink; a cold heat-exchanger (CHEX); by reciprocating the flow. Finding a way to keep the heat transfer high even in the presence of small temperature differences can lead to an improved engine design. We investigate the introduction of large-scale flow structures by employed an axial vortex generator to generate turbulent vortices to increase advective transport of heat from the HHEX and CHEX to the fluid. In this work; the design of the reciprocating fluid system; containing HHEX; CHEX; reciprocating system; vortex generator; and the test section is described. Non-dimensional numbers defining the flow conditions of the experiment such
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David S. Nobes; Faculty of Engineering; dnobes@ualberta.ca	as Richardson number and kinetic Reynolds number are defined and discussed.
Real-time monitoring of Oil Sand Pipelines by Wireless Communications **Khajepour, Somayeh** **skhajehp@ualberta.ca**	Real-time monitoring of oil sand pipelines is our final aim. So to derive this goal; we had to design a wireless battery free structure to monitor SAGD pipelines. We focus on creating sensor arrays distributed at critical locations along the slotted liner. We presented a wireless power and data transfer system to power a large number of sensors and transfer their data to the surface by developing a RFID based system for real time monitoring of SAGD pipeline environmental parameters such as temperature (which is about 300°C); pressure and humidity. As these sensors and tags are going through underground; providing power for them would be crucial. They could be supplied by wireless power transferring method. So designing a battery free RFID tag is required. Another critical parameter is operation frequency which determines the loss of communication link between tag and reader. So the array of tags and readers would be placed on the pipeline to provide real time SAGD pipeline monitoring.
Parametric Study on Flywheel Energy Storage Systems and Variable Effect Analyisis **Kuffert, Garen** **garenkuffert@gmail.com** Miles Skinner - maskinne@ualberta.ca; Pierre Mertiny - pmertiny@ualberta.ca	Flywheel energy storage systems (FESS) are increasingly becoming more popular for research purposes and industrial applications such as rapid electric vehicle charging stations due the long lifespan; exceptional efficiency; and high power capacity. This study seeks to determine the effect of the typical design variables for composite flywheel rotors on energy capacity and likelihood of failure. The Tsai-Wu failure criteria will be used for failure predictions and the angular velocity is used to determine the energy capacity. To predict failure and stress levels throughout the flywheel a model was developed in Matlab to simulate the stress state at any desired point in the flywheel. A two-level factorial design of experiments (DOE) problem was generated using the six design variables chosen for this study to determine the effect of each on the flywheel rotor.
Atomic Layer Deposition of Transition Metal Oxide Catalysts for Zinc-Air Batteries **Labbe, Matthew** **labbe@ualberta.ca**	Cost-effective energy storage is necessary to integrate renewable energy into the power grid. Zinc-air batteries are a promising and low-cost energy storage option; with superior safety and energy density as compared to Li-ion batteries. However; slow reaction rates at the air electrode limit practical power output. Catalysts are thus employed at the air electrode to overcome this limitation and improve the energy efficiency. While conventional catalysts utilize expensive precious metals such as platinum and ruthenium; research into catalysts constructed from more abundant and inexpensive materials will improve the accessibility of zinc-air technology. This work explores transition metal oxides; in particular manganese and iron oxide; as low-cost catalysts for zinc-air batteries. The catalyst layers are created through atomic layer deposition; which is able to conformally coat the surface and porosity of the air electrode to improve battery performance.
Optimization of growth and polyhydroxybutyrate (PHB) production in the alphaproteobacterial methanotroph Methylocystis sp. Rockwell **Lazic, Marina** **lazic@ualberta.ca** Hem Kanta Sharma; Dominic Sauvageau; Lisa Stein	CH4 represents the sole carbon source for a group of bacteria known as methanotrophs. Methanotrophs convert CH4 into metabolites that drive biochemical processes during active bacterial metabolism. The metabolite of interest in this project is the biopolymer PHB; a precursor for the production of bioplastic; and the producing bacterial strain is Methylocystis sp. strain Rockwell. We used a global metabolomic approach to analyze the effects of carbon and nitrogen source on metabolite pools during active bacterial growth. In addition; we developed two methodologies for PHB detection– (fluorescent NBA and sfGFP-linked); which are cheaper and faster than the standard GC-FIC approach. Results of our studies showed that the highest biomass follows the lowest PHB content in M. sp. Rockwell; indicating the need for further optimization. Furthermore; we confirmed the accuracy of the fluorescent NBA approach for PHB detection and we established a proof of concept for sfGFP-linked PHB detection
Role of Halides in Renewable	To combat climate change; there has been a necessary rise in research into renewable

Perovskite Energy Materials	energy such as solar power generation and storage. One promising class of materials are perovskites with the generic formula ABX3. The objective of my project is to explore the structure of halide chemical environments in lead-based perovskites (in which B = Pb and X = Cl; Br or I). I will discuss both the halogen environments in Pb-based perovskites; the current leading material in research; as well as the results of our search for a more environmentally-conscious; Pb-free alternative. To explore their intricate atomic-level structures and ionic mobility; I use solid-state nuclear magnetic resonance (SSNMR) spectroscopy. The expected outcomes of this research include gaining a deeper understanding of how the materials' properties and function can be controlled and identifying an effective new solar energy material.
Lin, Katherine **kylin@ualberta.ca**	
Riley Hooper; rhooper@ualberta.ca; Science; Diganta Sarkar; dsarkar@ualberta.ca; Science; Guy Bernard; gbernard@ualberta.ca; Science; Vladimir K. Michaelis; vmichael@ualberta.ca; Science	
Completely Earth-abundant Sunlight-driven Water Splitting Photo Electrodes	The conversion of sunlight and water into oxygen; protons; and electrons (water splitting) is a necessary component of any solar fuels system. Pursuing efficient; low-cost; and simple catalyst-dye systems to promote water splitting as among the most important goals of solar fuels research as a method to address climate change caused by CO2 emissions. We have; for the first time attached simple; organic N-Heterocyclic Carbene dyes (NHCD) to TiO2 nanoparticle electrodes. The dyes appear stable during visible light water splitting reactions under neutral and basic conditions. We have also deposited the NHCD onto high surface area; epitaxially grown; rutile TiO2 nanowire arrays. We are developing novel and known methods to deposit earth abundant Ni-Fe and Co-Phosphate water oxidation catalysts to the NHCD on TiO2 nanoparticle; and nanoarray electrodes. I will report the activities and stabilities of these novel; completely Earth-abundant sunlight-driven water splitting photo electrodes.
Liu, Jinkun **jinkun1@ualberta.ca**	
Loorthuraja Rasu; rasu@ualberta.ca; Science; Eric Beaulieu; ebeaulie@ualberta.ca; Engineering; Elissa Yao; jyao11@ualberta.ca; Science; James Pearson; jwpearso@ualberta.ca; Science; Octavio Martinez; martnezp@ualberta.ca; Science; Mike Donohoe; mdono015@uottawa.ca; Science	
Microlens-enhanced Photolysis of Contaminants in Water	The key issue of photodegradation is how to make use of light more sufficiently. Our project is aimed at exploring the potential of surface microlenses (MLs) fabricated from surface droplets for enhanced efficiency of photodegradation. In this work; we chose methyl orange (MO) as the model compound to evaluate MLs performance in photodegradation. The kinetics and mechanism of MO photodegradation in a sealed chamber were studied to see how the MLs affect the reaction process. The strong focus effect of surface MLs enabled light redistribution in the system and enhanced the degradation efficiency of MO without altering the reaction pathway. The influence of environmental factors on the effect of MLs was also investigated. According to simulation and experimental results; the MLs array with higher curvature was proven to increase the photodegradation efficiency most by 231%. Based on the research; surface MLs are promising to improve the efficiency of photodegradation in water treatment.
Lu, Qiuyun **qiuyun@ualberta.ca**	
The techno-economic assessment of alternative materials for hydrogen production via photocatalytic water splitting	Hydrogen (H2) can play a critical role in global greenhouse gas (GHG) mitigation. Photocatalytic water splitting using solar radiation is among the promising H2 technologies. Titanium dioxide (TiO2) and graphene (g-C3N4) based photocatalysts are the most widely used photocatalytic materials because of their activity under visible light and abundance in the earth's crust. Several attempts have been made to improve the photocatalytic performances of those materials in terms of their activity levels; life spans; responses to visible radiation; and stabilities. However; evaluation of the economic viability of large-scale deployment of those modifications is scarcely addressed in the existing literature. This study; therefore; aims to develop a bottom-up techno-economic assessment framework to determine the cost of hydrogen production of four alternative pathways. The results suggest that TNR has the lowest cost at 4.9 $/kg of H2 and a payback period of 0.8 years.
Maurya, Jayranjan **jayranja@ualberta.ca**	
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Engineering	
Autonomous localized energy exchange: an economy driven approach to transactive energy	High adoption of distributed energy resources can negatively impact electricity system stability, including voltage violations, through excess feed-in (photovoltaic installations) or sharp load demand spikes (electric vehicles). To address the above issues, we propose autonomous localized energy exchange (ALEX), an economy-driven transactive energy framework for real-time energy resource coordination. We then identify and investigate requirements for ALEX to form emergent, self-coordinating localized energy management systems. We test several market mechanisms for compatibility with ALEX using reinforcement learning. In result, we identify a suitable market mechanism that allows the agents to successfully learn how to price energy according to the supply-demand equilibrium.
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Steven Zhang shida1@ualberta.ca, Petr Musilek pmusilek@ualberta.ca	
Searching new spinel compounds using machine learning approach	Spinels are a class of minerals having several important applications such as electrode materials in lithium-ion batteries; electrocatalysis; superconductivity; etc. A spinel can adopt either normal or inverse crystal structure. The type of structure is decided by multiple factors such as the relative size of constituent metals; Madelung constants; ligand field stabilization energies; etc. The machine learning approach is being utilized considering these factors to explore new members of spinels family with specific properties.
Mishra, Vidyanshu vidyansh@ualberta.ca	
Alexander S. Gzyl; Balaranjan Selvaratnam	
Scale up study on pipeline hydro-transportation of agricultural and forestry residues	The quandary of continuous operation and technology upscaling of biomass-based conversion facilities due to the high cost of transporting feedstock has effectuated research in the field of hydro-transportation of biomass slurries. At present; there is no well-established and validated method for scaling-up pressure-drop data for biomass slurries obtained from smaller pipe diameters to larger pipe diameters. This study seeks to address this issue by designing and commissioning a 4-inch biomass slurry pipeline system and then conducting experiments to establish the relationship between flow parameters and slurry pressure drop. The study will further compare the results obtained from the 4-inch pipeline system with already established results from a 2-inch pipeline system. This will enable better prediction of slurry pressure losses at larger scales and thereby ease the economics of integrating biomass slurry pipeline technology with technologies like hydrothermal liquefaction.
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Vinoj Kurian; vinoj@ualberta.ca; Engineering; Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	
Hydrogen from water electrolysis: a combined experimental and numerical study	Energy storage will allow for the widespread deployment of renewable energy technology; as it solves the problem of the intermittency of the wind and solar energy. Long term storage at large scales will most likely be achieved by generating hydrogen gas using water electrolysis; however the most commonly used technology; PEM electrolysis; is presently too costly to be widely used. This work focuses on improving electrolyser performance and reducing its cost by using both experimental and numerical research. It has been shown that the electronic conductivity of a state of the art anode catalyst layer; where the water is split into oxygen and protons; can be extremely low; despite delivering good performance. Numerical modelling shows that the low conductivity means that most of the layer is not utilised; potentially allowing for a significant reduction in layer thickness. The thinner layer will use less expensive iridium catalyst; resulting in a significant cost reduction.
Moore, Michael mmoore2@ualberta.ca	
Compare Impact of Maximum Power Point Tracking methods of Wind Farms on Turbine Bearings	Market penetration of wind energy conversion systems can be further increased by reducing its energy payback time. To this end; the reliability of wind farms should be high. Also; wind turbines should be operated at their optimum point to harvest maximum power. In the conventional approach; each wind turbine is operated at its MPP. However; it gives rise to wake in the wind stream because of the complex interaction with rotor

Nayanasiri, Millawithanachchige Dulika nayanasi@ualberta.ca Yunwei Li; yunwei.li@ualberta.ca; Engineering; Brendan Calef; calef@ualberta.ca; Engineering	blades. Hence; energy extraction of the downwind turbines is impacted. Therefore; maximum power point tracking methods based on the entire wind farm has gained popularity to increase the overall energy harvest. In this study; the impact of the maximum power point tracking strategies on the lifetime of the main bearing is investigated. To this end; SCADA system data sets of meteorological tower and turbines are employed. Bearing damage is obtained using models and compared to evaluate the effectiveness of each MPP strategy in terms of the power and energy yield.
Performance of a Modified Drive Mechanism on a Low Temperature Differential Stirling Engine **Nicol-Seto, Michael nicolset@ualberta.ca**	Stirling heat engines produce mechanical work from any external thermal source and sink with a sufficient temperature difference. The closed thermodynamic cycle of the engine operates via sequentially heating; expanding; cooling; and compressing a gaseous working fluid inside the engine. The theoretical maximum work produced per engine cycle occurs when the thermodynamic processes are discrete processes. However; for nearly all practical Stirling engines; the slider-crank mechanisms of the drive mechanism results in process overlaps that reduce the work per cycle when compared to the ideal case. This work highlights the performance of a lab scale Stirling engine that was modified with non-circular gearing in the drive mechanism that better replicates the discrete processes of the ideal cycle. Presented results will include evaluation of the changes of the thermodynamic indicator diagrams; engine power and torque curves; and assessment of engine efficiency.
Biochars have a greater adsorption capacity for lead(II) from aqueous solutions than hydrochars **Nzediegwu, Christopher nzediegw@ualberta.ca** Yadi Tang; yadi4@ualberta.ca; Faculty of Agricultural; Life & Environmental Sciences; M. Anne Naeth; anaeth@ualberta.ca; Faculty of Agricultural; Life & Environmental Sciences; Scott X. Chang; sxchang@ualberta.ca; Faculty of Agricultural; Life & Environmental Sciences	We evaluated lead(II) removal capacity, and the associated mechanisms of biochars and hydrochars produced from canola straw, manure pellets, sawdust and wheat straw with microwave-assisted pyrolysis and hydrothermal carbonization. Regardless of the feedstock type, increasing process temperature increased and decreased lead(II) removal for biochars and hydrochars, respectively, due to changes in solution pH driven by char pH. Maximum lead(II) adsorption capacity was 4.0 to 165.1 mg g -1 for biochars and 2.8 to 24.4 mg g -1 for hydrochars, with the highest for the biochar produced from canola straw at 500 °C. Precipitation and cation-π interaction were the major mechanisms for lead(II) removal by biochars and hydrochars, respectively. We conclude that biochars outperformed hydrochars in lead removal from aqueous solutions, suggesting that biochars are preferred as adsorbents for the remediation of lead(II) contaminated water.
Generation Of Lipids In Microbes Grown On Mixed C5 And C6 Sugar Streams For Biofuel Production **Okafor, Damaris damaris@ualberta.ca** 1. Michael Chae; mchae@ualberta.ca; ALES 2. Justice Asomaning; asomanin@ualberta.ca; ALES 3. David C. Bressler; dbressle@ualberta.ca; ALES	Advancement in science and technology has resulted in the use of alternative feedstocks for biofuel production. The use of lignocellulosic feedstock is economically feasible; environmentally safe and sustainable; but due to the complexity of its structure; multiple carbon sources (C5 and C6) are present in lignocellulosic hydrolysate which poses a challenge to the production of microbial lipids for biofuel production. This research studied the growth and simultaneous utilization potential of C5 and C6 sugars by P. tsukubaensis; P. hubeinsis and C. iriomotense in nitrogen limiting mixed sugar media for microbial lipid production. Growth of the organisms and the residual sugar concentrations in the growth medium were analyzed. Levels of microbial lipids from each organism for a period of 5-10 days were determined gravimetrically. The results obtained in these experiments will help to assess the feasibility of using these microbes for biofuel production from lignocellulosic feedstocks.

Study of multilayer arrangements of bifunctional catalyst layers for PEM-Unitized regenerative fuel cell systems fabricated by ink-jet printing	Unitized regenerative fuel cells (URFC) are electrochemical devices that can work as fuel cells and electrolyzers as needed; their high specific energy density makes them an attractive solution for intermittent renewable energy sources by hydrogen storage. Cell performance is affected by the bifunctional catalyst layers' (BCL) fabrication method. Deposition of ORR and OER catalysts in separate layers is an alternative method that has shown limited but promising results; with the potential for optimization. We present a study of multilayer BCLs for a PEM-URFC with different arrangements of Pt and IrOx deposited by inkjet printing. The different configurations consisted of layers of each catalyst alone; a layer of mixed catalysts and multilayer arrangements of both. Preliminary results show that the performance of the different BCL mainly depends on the order of the deposition; showing an enhanced performance of each mode when the corresponding catalyst is in contact with the membrane.
Padilla, Luis **padillau@ualberta.ca**	
Dr. Marc Secanell; Dr. Natalia Semagina	
Water-use implications of low-carbon pathways in the oil sands	While many strategies to mitigate GHG emissions from oil sands production have been proposed; associated water-use impacts of these strategies have not been assessed to a comparable degree; despite the crucial nexus between energy and water in this sector. This research builds on a data-intensive model of oil and gas production in Canada. We evaluate alternative low-carbon oil sands energy supply pathways such as cogeneration; carbon capture-utilization-storage; nuclear; biomass; geothermal; wind; and solar. Key results for each pathway include the GHG abatement cost; cost of saved water; and the water cost of abated GHG compared to baseline.
Patrick, Thomas **thomas.patrick@ualberta.ca**	
Matthew Davis; mbdavis@ualberta.ca; Engineering; Amit Kumar; Amit.Kumar@ualberta.ca; Engineering	
Carbon Black and Hydrogen Production: An Optimized Reaction Mechanism for Methane Pyrolysis	Methane pyrolysis can be used to convert methane into carbon black and hydrogen without any greenhouse gas emissions. During the process; other species; such as acetylene; ethylene and ethane; are also observed. Accurate prediction of these species requires a reaction mechanism to help understand the reaction kinetics. However; a mechanism that accurately predicts this process in the temperature range of 1000-1400 K and 0.1-4 atm is missing. A previously proposed mechanism was modified in this work; and the optimal values of the pre-exponential factors were obtained using optimization. An improvement in the model predictions was observed once the optimal pre-exponential factor values were implemented in the mechanism. The numerical results were validated against the experimental data obtained from the literature and; additionally; compared to the data obtained from an in-house batch reactor experimental facility. The model can be used to design better methane pyrolysis experiments.
Punia, Ambuj **ambuj@ualberta.ca**	
James Tatum; jtatum@ualberta.ca; Engineering; Larry Kostiuk; lkostiuk@ualberta.ca; Engineering; Jason Olfert; jolfert@ualberta.ca; Engineering; Marc Secanell; secanell@ualberta.ca; Engineering	
Two-Stage Stochastic Optimization of a Virtual Power Plant	We present a revenue maximization strategy for a prosumer who owns and operates a solar farm and an Electric Vehicle (EV) charging station supporting vehicle-to-grid technology. The prosumer places energy bids a day in advance; to the day-ahead market. On the delivery day; a deficit in solar generation is likely due to the stochastic nature of solar power. The prosumer leverages the EVs' flexible charging schedule and trades energy in the imbalance market; mitigating the solar generation deficit. In addition; it ensures EVs are charged to their desired state-of-charge before departure. Considering the uncertainty of market prices; renewable generation; mobility; and demand of EVs; maximizing the revenue over a time horizon is a difficult task. In this work; we propose online and offline algorithms for maximizing revenue in the two markets while satisfying the demand of EVs. The offline algorithm solves an optimization problem under an oracle with perfect knowledge of the future.
Rahman, Saidur **saidur@ualberta.ca**	
Omid Ardakanian; oardakan@ualberta.ca; Faculty of Science	

Introducing a High-Pressure High-Temperature Testing Infrastructure to Advance Thermal Well Technologies	This poster presents the main features of a High-Pressure High Temperature (HP-HT) testing infrastructure. The equipment is designed and manufactured in the Faculty of Engineering at the University of Alberta to advance technologies for optimal oil recovery and wellbore completions for thermal wells. The technologies aim to lower water usage in Steam-assisted Gravity Drainage (SAGD); reducing the carbon footprint and water waste. The setup is unique in integrating the wellbore completion with the porous medium; incorporating wellbore screen-porous medium interaction in fines migration; mineral and organic scaling; and screen plugging and corrosion at actual wellbore conditions.
Salimi, Mahmood **msalimi@ualberta.ca**	
Arian Velayati; Hoda Dadjou	
Flywheel Energy Storage Systems for Electric Vehicle Charging Applications	Implementing electric mobility is a pivotal step in Canada's goal to achieve net-zero emissions by 2050. Current electric vehicle (EV) trends and future growth projections indicate the need for increased; robust charging networks. However; consequential electric grid challenges may emerge due to the rise in charging power of fast chargers and the high utilization of public charging infrastructure. High-power demand from the electric grid can lead to intense peak loading and grid instability. To address these issues the integration of flywheel energy storage systems (FESS) within fast-charging stations is considered. By acting as an energy storage buffer; high power can be provided to mitigate grid loads. FESS are recyclable and modular; and offer high charge/discharge cycle life; bi-directional power transfer ability; an accurately known state of charge; which makes them a feasible candidate. Academic research and commercial development effort are currently ongoing internationally.
Sarkar, Soumitra (Sam) **soumitra@ualberta.ca**	
Assessment of Target Analytes Using Solvent Exchange Developed Immobilized Surface Gold Nanocraters	Here; we demonstrate the surface immobilized gold nanocraters (GNCs) formation by using surface nanodroplets and the potential application in surface-enhanced Raman scattering spectroscopic (SERS) quantifications of analytes with high sensitivity. We investigated the effects of the precursor concentration & reaction time on formation; growth and final morphology of surface-bound GNCs. Surface nanodroplets that are positioned in an array of hydrophobic chemical micropatterns with hydrophilic background are sculpted as nanocraters after reduction of gold precursor by citrate exchange. Using SERS with GNCs; we will determine optimized extraction efficiency and enhancement SERS intensity by tuning droplet composition with thiol and substrate temperature after exchange process. The quantitative determination and detection by SERS using these GNCs for hydrophobic model compounds such as harmful environmental dye is helpful in environmental pollution monitoring by on-site portal Raman device.
Satyavir Dabodiya, Tulsi **tulsi2@ualberta.ca**	
Tulsi Satyavir Dabodiya;* tulsi2@ualberta.ca; Department of Chemical and Materials Engineering; Centre for Nanoscience and Technology; Pondicherry University; Haitao Yu; haitao.yu@rmit.edu.au; School of Engineering; RMIT University; Miaosi Li; miaosi.li@rmit.edu.au ; School of Engineering; Xuehua Zhang ; xuehua.zhang@ualberta.ca ; Department of Chemical and Materials Engineering	
Unravelling the Interaction of Water-in-Oil Emulsion Droplets via Molecular Simulations and Surface Force Measurements	In this work; molecular dynamic (MD) simulations were conducted on the water-in-oil emulsion droplets with the presence of surface-active components; including a model asphaltene (VO-79) and two model demulsifiers: PEO5PPO10PEO5 triblock copolymer and Brij-93. At the surface of water droplets; films were formed by the adsorbate molecules which redistributed during the approaching of the droplets. The redistribution of PEO5PPO10PEO5 was more pronounced than Brij-93 and VO-79; which contributed to lower repulsion during coalescence. Also; the interaction forces during droplet coalescence were measured using atomic force microscopy (AFM). Both simulation and force measurement results suggest that low dosage of the triblock copolymer may
Sun, Xiaoyu **xsun4@ualberta.ca**	

Xiaoyu Sun; xsun4@ualberta.ca; Department of Chemical and Materials Engineering; Diling Yang; diling@ualberta.ca; Department of Chemical and Materials Engineering; Hao Zhang; hao.zhang@ualberta.ca; Department of Chemical and Materials Engineering; Hongbo Zeng; Hongbo.Zeng@ualberta.ca; Department of Chemical and Materials Engineering; Tian Tang; ttang1@ualberta.ca; Department of Mechanical Engineering;	destabilize the water droplets by lowering the repulsion during coalescence; while high dosage could stabilize the droplets to prevent drop coalescence and bridge the droplets during separation.
Biomass production of Methylomicrobium buryatense 5GB1C using two types of advanced bioreactor operations **Tan, Yusheng yusheng@ualberta.ca** Lisa Y. Stein; stein1@ualberta.ca; Science; Dominic Sauvageau; dominic.sauvageau@ualberta.ca; Engineering;	While many species of methanotrophs can convert low-value methane and/or methanol into valuable bioproducts in bioreactors; Methylomicrobium buryatense 5GB1C stands out as one of the most industrially promising strains. This is due to its relatively short doubling time; great resilience against contamination; and the availability of genetic tools. Common batch reactor (BR) operation has important limitations when growing M. buryatense 5GB1C on methanol. For example; initial methanol concentration must be limited to avoid toxicity; leading to mediocre biomass productivity. Herein; two advanced modes of operation – fed-batch and self-cycling fermentation (SCF) – have shown a 26-fold increase in biomass density and a three-fold increase in volumetric productivity; respectively. These modes of operation thus greatly improved M. buryatense 5GB1C bioconversion and demonstrated great potential towards efficient implementation in industrial fermentation.
Development and Application of GCAM-Canada Model for Future Energy Scenario Analysis **Vannucci Chiappori, Diego chiappor@ualberta.ca** Evan G.R. Davies - Civil Engineering - evan.davies@ualberta.ca ; Evan. J. Arbuckle - Civil Engineering Master Student - ejarbuck@ualberta.ca ; Matthew Binsted - Joint Global Change Research Institute; Pacific Northwest National Laboratory; College Park; MD; USA; Maria Candelaria Bargero - Joint Global Change Research Institute; Pacific Northwest National Laboratory; College Park; MD; USA; Osama Younis - Civil Engineering Ph.D. Student - oyounis@ualberta.ca; Muhammad-Shahid Siddiqui - Economic Analysis Directorate; Environment and Climate Change Canada; Gatineau; QC; Canada;	To better understand the impacts of energy and environmental policies and their trade-offs across multiple sectors of the economy requires integrated assessments that combine multiple sectors into single; consistent simulation models. This research focuses on improving the capabilities of an integrated assessment model (IAM) called the Global Change Analysis Model (GCAM) to better represent Canadian future energy and environmental scenarios. Currently; Canada lacks an IAM capable of connecting multiple sectors and representing provincial energy supply and demand. GCAM-Canada has been built over the past several years to simulate and compare multiple scenarios at a 10-province and 3-territory scale; providing a helpful tool to support the decision-making process regarding energy resources development; GHG emissions targets; and environmental policies. The preliminary results showcase how different vehicle electrification scenarios up to 2050 impact the energy profile of each region.

Examining the application of microwave annealing for the optimization of organic photovoltaic solar cells	The transition to renewable energy sources has propelled the development of more efficient; inexpensive; versatil; and easier to manufacture solar cell technologies. Organic photovoltaic solar cells (OPVs) could meet these requirements. At their heart is the bulk heterojunction; a blend of organic donor and acceptor semiconductors in which solar radiation is converted into electrical charges that are then extracted to do work. Critical to their function is the generation of a nanoscale morphology of the donor and acceptor materials; and typically a processing step is required. Thermal annealing is such a treatment; here we examine the application of microwave heating; which could be a faster and more efficient approach to anneal OPVs. We will share characterization data of microwaved solar cells to determine if this annealing method is a feasible approach for the large-scale optimization of OPVs.
Velazquez Osorio, Adrian **avelazqu@ualberta.ca**	
Brian C. Olsen; bcolsen@ualberta.ca; science; Erik J. Luber; eluber@ualberta.ca; science; Tate C. Hauger; haugertc@gmail.com; science; Jillian M. Buriak; jburiak@ualberta.ca	
On the role of coherent flow motions in the breathing of a turbulent separation bubble	The low-frequency unsteadiness of the turbulent flow separated near the trailing-edge of a NACA 4418 airfoil was investigated at a chord-based Reynolds number of 720;000 and angle-of-attack of 9.7°. Time-resolved planar particle image velocimetry was performed in a measurement plane that was near and parallel to the airfoil surface. The spectral analysis of the streamwise fluctuating velocity showed that the peak frequency appeared near the mean separation point and at a Strouhal number of St = 0.03. The dominant energetic mode obtained from proper orthogonal decomposition of the velocity field was attributed to the large-scale movement of the separation front. The temporal coefficient of this mode has a peak frequency St of 0.03. The space-time correlation between the location of the instantaneous separation front and streamwise velocity demonstrated that the undulation of the separation front was associated with the low and high-speed streaks of the incoming boundary layer.
Wang, Sen **sen6@ualberta.ca**	
Sina Ghaemi; ghaemi@ualberta.ca; Faculty of Engineering	
A 3rd Harmonic Power Based Open Conductor Detection Scheme	Detection of open conductor condition in a system with unloaded Y_g connected primary transformers has been a challenging task. This is due to the lack of detectable abnormal voltage and current responses when a conductor opens. This paper recognizes that the above situation is related to the positive sequence nature of the supply voltage. If the supply voltage were in zero-sequence; an open conductor would result in distinct voltage and current responses. Based on this understanding; a relaying scheme that uses the 3rd harmonic power is proposed to solve the open conductor detection problem. Performances of the proposed method have been evaluated using simulation and experimental studies. The proposed scheme can be easily implemented using a relay similar to the zero-sequence power relay. Extensive study results show that the proposed method is a promising technique to solve the open conductor detection problem.
Wang, Xi **xw3@ualberta.ca**	
Wilsun Xu; wxu@ualberta.ca; ECE	
Specific Surface Free Energy of Ice and Clathrate Hydrates	Clathrate hydrates are compound in which guest molecules being trapped in cages formed by water molecules. It has promising applications in gas storage; gas separation and so on. But its formation should be inhibited in pipelines considering flow assurance. Therefore; its formation kinetics is of vital importance. This abstract compared the specific surface free energy of ice to that of THF (Tetrahydrofuran) hydrate at 4℃ using the Zisman plot method. Flat THF hydrate and ice surfaces were prepared. Several halobenzene; fluorocarbon and hydrocarbon liquids were used as the testing liquids. The contact angle (θ) of the testing liquids on THF hydrate and ice surfaces and the surface tension of testing liquids were measured at 4℃. From this information; a Zisman plot was established and the critical surface tension deduced. The results show that THF hydrate had a slightly smaller critical surface tension than that of ice.
Wei, Yu **ywei8@ualberta.ca**	
Nobuo Maeda; nobuo@ualberta.ca; Faculty of Engineering	
Analyzing the spatiotemporal variation of urban heat islands	Urban heat island (UHI) refers to an area in a city that is much warmer than its rural surroundings. This study explores whether there was a significant change in UHIs across

with land use changes: A case of Edmonton; Canada **Welegedara, Nilusha** **yalingas@ualberta.ca** Sandeep Agrawal; sagrawal@ualberta.ca; Faculty of Science; Ghazal Lotfi; lotfi@ualberta.ca; Faculty of Science	neighbourhoods in the city of Edmonton over the last two decades. We used Landsat satellite images from 2000 to 2020 acquired during summer and winter periods to generate land surface temperatures and land use maps. Results indicate a significant UHI increase within residential neighbourhoods particularly in developing neighbourhoods over the last two decades. The temperature increase in these neighbourhoods was strongly linked to the reduced vegetation and increased built-up areas. We also noticed that in summer; the surface temperature difference in some industrial and residential neighbourhoods within the city showed an increase of 4-90C compared to surrounding rural areas. Outcome of this study will help municipal planners and policy-makers develop heat mitigation and adaptation strategies for neighbourhoods.
Interface decomposition for solid all solid state batteries **Xie, Geng** **gx@ualberta.ca**	Developed from last century; the most widely use LiCoO2 batteries with liquid electrolyte have been studied for years but almost reach their performance limit. A potential candidate for next generation battery is solid electrolyte battery. However; our understanding of electrochemical change and decomposition solid-solid interface; which limits the further selection of electrolyte and protecting materials. This project studies the mechanism of decomposition occurs at the electrode/electrolyte interface in solid state batteries. Knowledge obtained from this project will provide insight into strategies that can suppress the interface decomposition. The project focuses on a sodium-based electrolyte - Na3SbS4. Compared to lithium; sodium is more cost-effective. The battery performances and decomposition chemistry were measured using a series of combined electrochemistry and spectroscopy methods. This project will establish a set of method for all-solid sodium battery characterization.
Enhanced photoinduced charge mobility and separation in the photocathode of Cu2O@rGO **Xu, Chenyu** **cx6@ualberta.ca** Mengnan Zhu; mzhu@ualberta.ca; Department of Chemical and Materials Engineering; Pengfei Sui; psui@ualberta.ca; Department of Chemical and Materials Engineering; Steven Bergens; steve.bergens@ualberta.ca; Department of Chemistry; Karthik Shankar; kshankar@ualberta.ca; Department of Electrical and Computer Engineering; Jing-Li Luo; jingli.luo@ualberta.ca; Department of Chemical and Materials Engineering	The fabrication of an efficient and low-cost photocathode still remains a big challenge. We herein report a CuxO@rGO photocathode for CO2 conversion. rGO was added to construct a “highway” for charge transfer in the bulk. Photoinduced charge carrier extraction based on linearly increasing voltage (photo-CELIV) measurements and transient photovoltage (TPV) was conducted to obtain the charge-carrier mobility in the photocathode samples. In the photo-CELIV tests; internal charge carrier transfer could be improved by nearly two times with the addition of rGO. To gain more insights into the photoinduced EHPs recombination; TPV measurements were performed. The rGO could improve the transfer and extraction of charge carriers; so the separation of EHPs could be reduced to extend the recombination time. CO; H2 and CH4 can be stably produced with dual photoelectrodes using a neutral solution.
Analysis of vibration characteristics of a spur gearbox with multiple teeth cracks using dynamic modelling **Yang, Xingkai** **xingkai2@ualberta.ca**	In industrial applications; due to their harsh working environment; gearboxes may suffer from tooth crack faults; including the scenarios of one tooth crack and multiple teeth cracks. To prevent gearbox failures due to tooth cracks; many studies have been conducted to diagnose tooth cracks. However; for the reported studies; they mainly focused on the scenario of only one tooth crack; failing to involve multiple teeth cracks. The scope of this study is to give some insights into the vibration characteristics of a spur gearbox with multiple teeth cracks. A lumped parameter model of a one-stage spur gearbox is developed to simulate the vibration responses of spur gears with multiple teeth cracks.

Ming J. Zuo; ming.zuo@ualberta.ca; Engineering; Zhigang Tian; ztian@ualberta.ca; Engineering	Simulated vibration responses are investigated in both time and frequency domains. Besides; a method is proposed to detect the number of teeth cracks based on the envelope analysis of the crack induced impulses; the effectiveness of which is verified by the analysis results of simulated signals.
Novel Earth Abundant Catalyst and Photosensitizer for Photocatalytic Carbon Dioxide Reduction Towards Solar Fuels **Yao, Elissa** **jing.yao2@mail.mcgill.ca** Mike Donohoe; mdono015@uottawa.ca; Science; Octavio Martinez Perez; martnezp@ualberta.ca; Science; Loorthuraja Rasu; rasu@ualberta.ca; Science; Steven Bergens; sbergens@ualberta.ca; Science	As greenhouse gas levels continue to rise; hurdling the planet towards climate catastrophe; the demand for cost-effective carbon dioxide conversion rises with them. A strong approach is to convert sunlight; carbon dioxide; and water by artificial photosynthesis into carbon-neutral fuels. Such systems must be cost-effective. Carbazole-dicyanobenzene dyes are recent; popular catalysts for photoreactions. We discovered that functionalizing these dyes with imidazole and N-heterocyclic carbene groups results in novel and efficient photocatalytic reduction of carbon dioxide when paired with [Re(bpy)(CO)3Cl] (bpy = bipyridine) or the Earth-abundant [Mn(bpy)(CO)3¬Br].¬ Hydrogen bonds likely activate coordinated CO2 towards reduction; facilitating electron transfer between the excited dye and the active sites. I will present the results from optimizations and mechanistic studies.
Bitumen Extraction by Using Non-thermal cyclic solvent process **Yousefi, Mohammad** **myousefi@ualberta.ca** Taregh Soleiman Asl; solieman@ualberta.ca; Faculty of Engineering	The main objectives of this study are to: i) understand the interaction between bitumen-propane at the bulk-phase at low temperature; ii) evaluate the solubility of propane in the bitumen at low temperature; and iii) investigate bitumen extraction mechanisms by liquid propane from an artificial sand pack during injection; soaking and depletion phases. We conduct novel visualization experiments by using a custom-designed; state-of-the-art high-pressure and high-temperature (HPHT) visual cell. The experimental results show that using a non-thermal cyclic solvent process; not only is effective in the oil-recovery; but also it can reduce the need of steam injection to recover the viscous bitumen in the oil-sands reservoirs. The outcome of the study can help the industry toward the future goal of the net zero emission by substituting thermal oil-recovery methods; therefore decreasing the greenhouse gases emission during thermal heavy oil production operations.
Wind farm predictive maintenance considering component level repairs and economic dependency **Zhang, Han** **hz13@ualberta.ca** Zhigang Tian; ztian@ualberta.ca	Existing studies on wind farm predictive maintenance mostly incorporated repairs on the level of wind turbine (WT) subassemblies; such as gearbox and generator. However; there are multiple components in a subassembly; whose failures could lead to different maintenance strategies. Besides; only fixed costs are considered on the WT and farm levels without differentiating fixed costs that apply to a subset of components can result in over-simplification. In this work; a wind farm predictive maintenance approach is developed considering component level repairs and economic dependency in a more realistic and accurate way. A predictive maintenance optimization model is developed to find the optimal maintenance policy. The number of WTs eligible for preventive maintenance is introduced as a new decision variable; which captures the economic dependency among WTs. A simulation-based method is developed for maintenance cost evaluation. Examples are used to demonstrate the proposed approach.
The Potential of Low-Grade Canola Feedstock for Biojet in Alberta: A GIS-Based Analysis **Zhang, Wenbei** **wenbei1@ualberta.ca**	Environmental concerns in the aviation industry are contributing to increased demand for green energy such as biojet. A potential feedstock for biojet in Canada is canola; which is typically used for vegetable oil. But canola harvests inevitably produce some low-grade seed; which is undesirable for making food-grade oil. Using low-grade canola as feedstock for biojet could benefit numerous stakeholders: biojet producers could benefit from reduced feedstock costs; farmers could benefit from alternative markets for low-value

Marty Luckert; mluckert@ualberta.ca; ALES; Feng Qiu; fq@ualberta.ca; ALES; Jay Anderson; jaya@ualberta.ca; ALES	canola; and policy makers and society could benefit by alleviating food versus fuel concerns. In this study; we assess available and accessible low-grade canola in Alberta; and identify potential new sites for seed crushing plants. Preliminary results from a township-level GIS analysis confirm multiple sites in Alberta that could supply low-grade oil for biojet production. Results also show substantial spatial and temporal variations in low-grade canola supply.
Carbon Based Materials For Remediation Of Cadmium And Zinc Contaminated Water **Zhao, Yihan** **yihan5@ualberta.ca**	Industrial release of heavy metals; such as during mining; may pose a significant risk to the environment and public health. Conventional heavy metal remediation treatments have high costs and energy use and low efficiency; making new technologies a significant research area. Batch experiments were conducted to investigate the adsorption mechanisms and behaviours of two lignite derived humic products (nano humus and humic powder) and a cattle manure derived biochar as adsorbents in removal of divalent cadmium and zinc from metal contaminated water. Humic materials followed the Freundlich isotherm and pseudo-second-order kinetic model; indicating multilayer adsorption. Cattle manure biochar followed the Freundlich isotherm and pseudo-first-order kinetics model; suggesting diffusion dominated multilayer adsorption. These mechanisms resulted in various efficiencies. Nano humus has the greatest potential as an effective; rapid; and inexpensive material in future heavy metal remediation.
Electrochemically Reconstructed Perovskite with Cooperative Catalytic Sites for CO2-to-Formate Conversion **Zhu, Mengnan** **mzhu@ualberta.ca** Co-authors: Bo-Wen Zhang(1); bzhang6@ualberta.ca ; Min-Rui Gao(1); minrui1@ualberta.ca ; Chenyu Xu(1); cx6@ualberta.ca ; Peng-Fei Sui(1); psui@ualberta.ca ; Hongbo Zeng(1); hongbo.zeng@ualberta.ca ; Karthik Shankar(2); kshankar@ualberta.ca; Steven Bergens(3); sbergens@ualberta.ca; Jing-Li Luo(1)*; jingli.luo@ualberta.ca; ; *Corresponding author: Jing-Li Luo(1)*; jingli.luo@ualberta.ca;(1). Department of Chemical and Materials Engineering; University of Alberta; Edmonton; Alberta; T6G 1H9; Canada; (2). Department of Electrical and Computer Engineering; University of Alberta; Edmonton; Alberta; T6G 1H9; Canada; (3). Department of Chemistry; University of Alberta; Edmonton; Alberta; T6G 1H9; Canada	Perovskites are promising catalysts for various reactions; yet their applications in room-temperature carbon dioxide reduction reaction (CO2RR) are less explored. Herein; we demonstrate that the reconstructed BaBiO3 (BBO) perovskite facilitates CO2-to-formate (FA) conversion by both A- (Ba) and B- (Bi) site elements through the cooperative but distinct catalytic mechanisms. Specifically; BBO reduction under extended electrochemical poling gives rise to bismuthene (eBBO) in situ due to the rapid kinetics of Bi exsolution from the parent scaffold. The as-obtain materials show high selectivity for FA production in both electrochemical and photoelectrochemical cells. Furthermore; the structural reconstruction of BBO has led to the release of Ba2+; and the effect of Ba2+ on CO2RR is dependent on the type of electrolyte; applied potential; and the final Ba2+ concentrations; as further validated by time-resolved FTIR and density functional theory calculations.