Otago Energy Research Centre

11th Symposium 2017

&

Ag@otago Colloquium 2017

Ag@Otago
Ahuwhenua ki Ōtākou, Rangahau
A UNIVERSITY OF OTAGO RESEARCH THEME

Abstract Booklet

Zeecol Limited

POWERco

CONTENTS

Presentations will be available on the OERC website shortly after the Symposium at: http://www.otago.ac.nz/oerc/symposia/

Find out more about OERC at: http://www.otago.ac.nz/oerc/

Watch our 2017 OERC Seminars on our YouTube channel: https://www.youtube.com/channel/UC9K_VzVKUSJr9FC2WSL9CYQ/videos

Follow us on twitter: https://twitter.com/OERC_at_Otago

For any further enquiries please contact Jane Wilcox at oercadmin@otago.ac.nz

KEYNOTE BIOS *(SURNAME ORDER)*

Simon Arnold
Chief Executive, National Energy Research Institute

Managing Director, Simon Arnold, is currently also part-time CEO of NZ's National Energy Research Institute (NERI). In that role he has been developing an Energy Research Strategy for NZ.

Simon has been active in industry organisations since having been CEO of the NZ Manufacturers Federation in the 1990s. Currently he is the convener of the Liquid Biofuels & Co-products interest group of the Bioenergy Association of New Zealand, and is assisting with the management of the Clean Tech Centre in Otaki, New Zealand. He is a past President and life member of the Wellington Chamber of Commerce, and chaired the Policy Council of Business Central.

Hugh Campbell
Professor University of Otago

Hugh Campbell is Chair of Sociology as well as Head of the Department of Sociology, Gender & Social Work at the University of Otago. He was also the Director of the Centre (formerly CSAFE) from 2000 to 2010. Hugh comes from the Waikato, with family in Hawkes Bay sheep farming and Taranaki dairying.

A long-term interest in issues involving agriculture and food has stayed with him in his subsequent career as a social scientist. Since 1995, Hugh has had a leadership role in two large research projects funded by the Ministry of Science and Innovation (MSI). From 1995-2002, he was the Programme Leader of an MSI-funded programme, Greening Food: Social and Industry Dynamics. This programme examined the social and economic dimensions of developing sustainable agriculture in New Zealand. Specifically, the programme examined the development of organic production and Integrated Pest Management systems by food export organisations like Zespri and ENZA. This provided a strong research base for Hugh's subsequent interest in food auditing, new governance structures in food chains, environmental auditing, and the necessity to shift New Zealand food exporting from 'quantities to qualities.'

Since 2003, Hugh has co-led the social research objective in the MSI-funded Agriculture Research Group on Sustainability (ARGOS) Programme. This programme is considered to be the largest current study of 'farm-scale' sustainability in the world. Working with the kiwifruit, dairy, and sheep/beef sectors, the ARGOS programme has brought together 30 researchers from Otago and Lincoln Universities, and from the Agribusiness Group in Christchurch. It is undertaking a long-

term study of social, economic and environmental dynamics on a group of over 100 farms and orchards in New Zealand.

Frank Griffin,
Emeritus Professor University of Otago

Frank Griffin is the Director of the Ag@Otago research theme at the University of Otago, a new initiative drawing on the strengths in plant and animal production, food and health, and sustainability. With over 40 years experience in the Department of Microbiology and Immunology he is a consultant to many international committees and consortia, and a member of societies of immunology and microbiology in New Zealand, Australia and the United States.
Professor Frank Griffin was the founding director of DRL, which has been carrying out research on mycobacterial diseases (tuberculosis/paratuberculosis) in ruminants and wildlife species for the past 35 years. In the past decade their work has led to the development of improved immunodiagnostics and molecular techniques for the detection of paratuberculosis (Johnes disease). DRL has recently identified deer breeds with polarised phenotypes for resistance and susceptibility to paratuberculosis. DRL is now a part of Otago Innovation Limited.

Martin Hohmann-Marriott
Associate Professor Norwegian University of Science & Technology

Martin Hohmann-Marriott is Associate Professor in the department of Biotechnology at Norwegian University of Science & Technology (NTNU). His research interest is in bioenergetics, especially the evolution of photosynthetic machinery in different organisms. Martin has worked on the photosynthetic machinery and physiology of green sulphur bacteria, cyanobacteria, green algae and heterokont algae. He is currently focussing on renewable energy and the application of structural approaches to address open questions in bioenergetics.
Martin has established PhotoSynLab, an 'open science' laboratory at NTNU that shares all protocols and publishes all experimental results online. PhotosynLab is intended to apply synthetic biology approaches and laboratory automation to explore photosynthetic organisms.

Suzi Kerr,
Senior Fellow, Motu

Suzi Kerr is currently a Senior Fellow at Motu and an Adjunct Professor at Victoria University. She graduated from Harvard University in 1995 with a PhD in Economics. From 1998 to 2009 she was Director and Senior Fellow at Motu. In 2010 she won the NZIER Economics Award. She has also worked at the University of Maryland at College Park, Resources for the Future (USA), the Joint Center for the Science and Policy of Global Change at MIT, and more recently was a Visiting Professor at Stanford University for the 2009/10 year and at the University of the Andes in Bogotá, Colombia in the first half of 2014.

Her current research work focuses on climate change. She empirically and theoretically investigates domestic and international climate change policy with special emphasis on emissions pricing and land use in both the tropics and New Zealand. She also leads work on climate change impacts and adaptation in New Zealand. She has previously worked extensively on economic instruments for managing water quality, fisheries and air quality. She has run four policy dialogue processes, one in the lead up to the establishment of New Zealand's emissions trading system, others on managing water quality in Lake Rotorua, on agricultural greenhouse gas emissions and (co-led) on New Zealand's Low Emissions Future, and she is currently leading a dialogue on New Zealand's ETS.

William Mook
CEO of Zeecol Ltd

William Mook serves as Chief Executive Officer, Secretary and Director of the Company. He has over 18 years of experience in the manufacturing industry as an original equipment manufacturer and also as a technology investor. He has over 20 years of experience as President and CEO of various companies including MokEnergy, Sugico Mok and Rapi-Serv Cash Systems.

He founded Zeecol Limited, a New Zealand company, in 2011, where he spent three years developing Zeecol's technology and two years structuring the company. He holds patents in a wide range of fields. In addition to his management and motivational skills he is an accomplished speaker and team builder. Mr. Mook is currently a remote teaching associate in the Physics and Energy department at Stanford University. Mr. Mook has been working under Dr. Robert Laughlin at Stanford, who, in 1998, received a Nobel Prize for the discovery of the Fractional Quantum Hall Effect.

Himadri B. Pakrasi,
Professor Director, International Center for Energy, Environment and Sustainability (InCEES) Washington University

Himadri B. Pakrasi, Ph. D., is the Myron and Sonya Glassberg/Albert and Blanche Greensfelder Distinguished University Professor and Director of the International Center for Energy, Environment and Sustainability (InCEES) at Washington University in St. Louis. He holds faculty appointments in the Department of Biology, School of Arts & Sciences and as a Professor of Energy in the School of Engineering & Applied Science.

Professor Pakrasi has been an Alexander von Humboldt Fellow at Munich University, Germany; a Distinguished Fellow at the Biosciences Institute, Nagoya University, Japan; and a Lady David Visiting Professor at the Hebrew University, Jerusalem, Israel. He is an elected Fellow of the American Association for the Advancement of Science, an elected fellow of the American Society for Microbiology and a Wiley Fellow at the Environmental Molecular Sciences Laboratory of the United States Department of Energy. Pakrasi serves as the Washington University ambassador from the McDonnell International Scholars Academy to the Jawaharlal Nehru University and Indian Institute of Technology, Delhi in India.

Pakrasi is a biochemist recognized for his work on photosynthesis and bioenergy production. He has a keen interest in bridging the differences between the biological and physical sciences, and has led large-scale multi-institutional systems and synthetic biology projects. The key areas of his research interest are systems biology, photosynthesis and synthetic biology.

Eric Pellicer
Network Transformation Manager at Powerco and Board Member at Drive Electric Inc.

Eric Pellicer is the Network Transformation Manager at Powerco, which is researching, developing and implementing innovative network and non-network solutions for Powerco.

In his role as Commercial Manager at Powerco, Eric also leads the customer and commercial side of the electricity business and is focused on lifting the engagement with consumers and integration of new energy technologies into the grid. Eric is also accountable for Powerco's Emerging Energy Consumers and Markets programme which is aimed at understanding what New Zealander's are looking for from their distribution utility now and in the future. Eric has been with Powerco (and in New Zealand) for over 6 years and prior to joining Powerco, worked as a management consultant for 10 across a number of sectors focusing on business transformation and strategic planning.

1. KEYNOTE: RESILIENCE AND RELIABILITY – INNOVATION AT THE GRID EDGE TO IMPROVE CUSTOMER OUTCOMES

Author: Eric Pellicer

Authors Affiliations: Network Transformation Manager at Powerco and Board Member at Drive Electric Inc.

From boiling a kettle to loading a ship, NZ runs on electricity. While each consumer uses power in different ways, what's common amongst all of them is 'when they need it, they need it' and distributors must play their part in ensuring that expectation is met as best as possible. Changes to technology and consumer preference however are adding many new and exciting dimensions to how we meet this expectation. But what does 'needing energy' really look like? Distribution systems are based on providing a set capacity and bank on consumer diversity to ensure all needs are met. But when a traditional approach won't work, how must we innovate to meet this need? From powering a town to powering a shearing shed, this presentation will explore how Powerco is approaching 2 unique challenges on its network with innovation and collaboration.

2. PV UPTAKE SCENARIOS AND THE RENEWABLE ENERGY TRANSITION

Author: Gerry Carrington and Janet Stephenson

Authors Affiliations: Centre for Sustainability, University of Otago.

Scenarios signal a range of plausible futures and thereby help inform the planning and decision-making undertaken by governments, businesses and investors. But what if scenarios consistently failed to represent a credibly established outcome, particularly for a topic as critical as the world's future energy systems? We examine solar photovoltaic (PV) projections in 30 recent global energy scenarios, contrasting them with academic studies and other forecasts, and find that none of the scenarios account for a plausible upper level of solar PV growth. We discuss the possibility that low projections may limit investments in innovation and development of PV, and thus constrain its potential to contribute to decarbonising world energy systems – a self-fulfilling prophecy. Indicating the plausibility of a rapid uptake in scenarios could encourage more investment in solar PV. This would drive a more rapid decarbonisation of the energy system, and improve the sector's preparedness for a smooth transition.

3. INVESTIGATION INTO THE STALLING BEHAVIOUR OF THE THINAIR 102 SINGLE-BLADED WIND TURBINE

Authors: P-Y. Potonnier a, S. J. Wakes b, G. Gabriel c, A. Dürbaum a, B. Currie a

Authors affiliations: a PowerhouseWind, Dunedin, New Zealand
b Centre for Materials Science and Technology, University of Otago, Dunedin, New Zealand
c Fakultät für Maschinenbau und Schiffstechnik, University of Rostock, Germany

ThinAir 102 from PowerhouseWind is a stall regulated single blade wind turbine designed for small-scale use. The controller regulates the rotation of the turbine to maximise power output. Stall is a mechanism used to limit power output above the rated output wind speed in order to maintain control and prevent damaging structural loads. Better understanding of the stall on the blade is crucial to optimising the controller software and therefore the power output. Several methods were used to better understand the stall behaviour of the ThinAir 102 blade including visualisation, two- and three- dimensional simulation models. Visualisation of the flow of wind over the blade was undertaken using a tuft method and a camera mounted on the turbine hub developed from a Masters thesis (Swytink-Binnema, 2014, University of Waterloo, Canada). The video was analysed frame by frame to determine if stall occurred. By coordinating the time of the controller and camera it was possible to map stall for different wind speeds and turbine rotational speed. Results are presented from the visualisation method and three-dimensional Computational Fluid Dynamics (CFD) simulation model to better understand stall on the ThinAir 102 blade. The application by PowerhouseWind of the "digital tuft flow visualisation method" is also discussed.

4. QUANTIFYING THE FINANCIAL AND ENVIRONMENTAL BENEFITS OF ELECTRIC VEHICLES IN NEW ZEALAND: EARLY RESULTS FROM FLIP THE FLEET

Author: Daniel Myall1, Jefferson Dew2, Henrik Moller2 & Dima Ivanov3

Author affiliations: 1 New Zealand Brain Research Institute, 66 Stewart St., Christchurch 8011

2 Ecosystems Consultants, 30 Warden St., Dunedin, 3 PowerStats, 131 Brightside Road, Auckland 0932

Over 400 owners of electric (EVs) have signed-up to contribute monthly data on their use and performance to Flip the Fleet's communal database. In this paper we illustrate the strengths and limitations of the data stream by presenting analysis of (i) data representativeness, (ii) participation rates, (iii) data completeness and errors, and (iv) some important outcomes for EV owners and wider society. The latter include preliminary estimates of (a) decline in battery 'State of Health' (a key determinant of EV range and rate of depreciation); (b) EV repairs and maintenance costs compared to those of Internal Combustion Engine (ICE) vehicles (a significant incentive to buy EVs); (c) proportion of propulsion powered by the battery rather than the ICE in Plug-in Hybrid vehicles (a key determinant of whether PHEVs will contribute to a low carbon transport future in New Zealand); and (d) a national extrapolation to plot the growing contribution of electric vehicles to mitigating climate change.

5. DESIGNING TRANSPORTATION SYSTEMS FOR QUALITY LIFE

Authors: Ben Wooliscroft and Alexandra Ganglmair-Wooliscroft

Authors affiliations: University of Otago

Currently New Zealand's transportation system is planned and justified on the basis of GDP and productivity. It is one of the most automobile centered countries in the world, with approx 800 cars owned for every 1000 citizens. That represents more cars (3.8million) than drivers (3.4million in 2015). Each of those cars emits carbon, particulate matter, causes inactivity, requires storage and major public spending. The mobility culture is broken, environmentally, socially and economically.

This research asks what our transport system would look like if it were planned to maximise the Quality of Life of New Zealanders. Active Transport is clearly associated with many positive outcomes for the individual, society, the environment and the economy. Given the overwhelmingly positive case resistance to putting active transport at the forefront of all transport decisions it is hard to understand the blindness to anything other than economic criteria, and ignoring the economic reality of a move to Active Transport.

The change in transportation infrastructure would not only have signicant postive impacts on the quality of life of New Zealanders, it would also have major impacts on fossil fuel use, air quality, the population's health and our attractiveness as a destination for tourists and highly skilled workers.

6. PREDICTING THE RATES AND PRODUCTS OF THE ELECTROCHEMICAL REDUCTION OF CO2 TO HYDROCARBONS AND ALCOHOLS USING COMPUTATIONAL METHODS

Authors: Mingrui Yanga, Javed Hussainb, Egill Skúlasonb, Anna L. Gardena

Authors affiliations: [a]Department of Chemistry, University of Otago; [b]Science Institute, University of Iceland

Global energy use has increased drastically in recent years due to a rapidly increasing population and modernization of society. Fossil fuels have largely been used to meet this energy requirement, which has given rise to two significant challenges: (1) Fossil fuel resources are being depleted and (2) CO2 produced by combustion of fossil fuels is perturbing Earth's atmosphere and having deleterious effects on global climate. While much effort is focussed on improving the efficiency of renewable energy processes such as hydro, solar and wind, these resources suffer from geographic limitations and intermittancy, preventing large scale deployment. A potential solution that could address both challenges simultaneously is the capture and conversion of CO2

to hydrocarbon-based fuels, such as methanol. By using electricity generated by renewable sources, captured CO_2 can be catalytically reduced to yield carbon-neutral fuels, provided an appropriate catalyst can be found.

Theoretical calculations are becoming increasingly used for rational catalyst design. A number of theoretical studies have been conducted on the electroreduction of CO_2 to hydrocarbons and alcohols but, until very recently, debate was rife over the reaction mechanism and thus the certainty with which the rate and products could be predicted. Recent work by some of us has shed light on this but the extent to which we can use these models for predicting the properties of new catalysts remains unknown. In the present work this will be addressed by systematic evaluation of the uncertainties in the rates and product distribution of CO2 reduction on a copper catalyst.

7. HOW GOOD ARE PEOPLE AT REPORTING THEIR ENERGY USE?

Authors: Kiti Suomalainen[a], Michael Jack[b], David Eyers[c], Rebecca Ford[d], Janet Stephenson[a]

Authors affiliations: [a]Centre for Sustainability, [b]Department of Physics*, [c]Department of Computer Science*, *University of Otago, [d]Environmental Change Institute, Oxford University*

Simulating residential consumers' energy-related activities has become an integral part of models of residential electricity use. This requires information about the timing and frequency of activities such as showering, cooking and using heaters. Time-use diaries are often used as a direct descriptor of occupants' activities in the house. However, the accuracy of reporting within time-use diaries is seldom verified or quantified.

Within the MBIE-funded GREENGrid project, we used precisely-measured electricity consumption data and time-use diaries collected over the same week to explore how accurately people report energy-related activities in households, and how often they misreport an activity. Our current research investigates the accuracy and precision of activities reported in time-use diaries related to hot water use and heat pump use.

With this research we are investigating whether reported activities are a good predictor of electricity use. In other words, what is the probability that there is actually electricity use in a certain time interval, given that an activity is reported? Or similarly, what is the probability that there is electricity use detected during an interval, given that no activity is reported in that time interval?

The results indicate that an activity reported in a diary is a reasonably good predictor of electricity use, but at the same time a large amount of activities that result in electricity use are not recorded in diaries. We believe that a larger study, with a more user-friendly, automated approach to reporting activities could be crucial for gaining further insights into energy-relevant human-technology interaction in households.

8.KEYNOTE: THE SCOPE OF RESEARCH ACTIVITIES WITHIN THE AG@OTAGO RESEARCH THEME

Authors: Frank Griffin

Authors affiliations: Director Ag@Otago, Director Disease Research Limited (DRL)

Ag@Otago was launched as a University Research Theme in April 2016. Within the Theme there are three distinct but interactive Subthemes Titled: I. Enhancing agriculture productivity, II. Adding value to primary products, III. Sustainable and profitable environmental management. Researchers involved with Ag@Otago encapsulate a wide range of expertise, involving every school within the University. Currently we are attempting to develop working relationships with individual leaders and policy makers within the agricultural sector. Our philosophy is that our future research should be transformational but shaped by the requirements of the primary sector, rather than the inclinations of researchers.

Ag@Otago's goal is to engage in translational research that enhances the Production of High Value, Residue-free, Branded Food, in Sustainable and Biodiverse Farming Systems. We are currently exploring how we can best become engaged with the diverse food production systems, already established, or emerging in the Food industry within New Zealand. This includes Conventional intensive farming, Alternative (Regenerative/Organic) farm systems, Hydroponics, and Biotechnology involving formulation of plant and microbial based synthetic foods. We are also keen to explore the nexus between food as a nutrient and the medicinal properties of foods. Our challenge is to find complementary pathways where the diverse players in the food production chain in New Zealand can enhance its International reputation for the production of high value residue-free food, within environmentally sensitive production systems.

The challenges we face, and the opportunities that are evident, will be discussed at the symposium.

9. KEYNOTE: CAN WE LIVE WITHOUT OIL AND GAS?

Authors: William Mook

Authors affiliations: CEO of Zeecol Ltd

It's a question of scale.
A barrel of crude oil weighs 309 pounds. It's $55.70 per barrel. $0.18 per pound. Fertiliser is made from natural gas through the haber process it is presently $0.36 per pound.

Retail Fertilizer Prices Start 2017 With Mixed Moves
https://www.dtnpf.com/agriculture/web/ag/news/crops/article/2017/01/11/retail-fertilizer-prices-start-2017
Now recycled waste comes from the leavings of our farming operations. A pint of milk weighs a pound. 8 large eggs weigh a pound. 3 large potatoes weigh a pound. 2–1/4 cups of sugar weigh a pound. Five Big Macs have one pound of their signature ground beef. It costs far more than $0.18 to $0.36 for any of these.

A pound of organic matter is far more expensive than a pound of primary energy. It must be. This has to do with Lindemans law of trophic change. Any organism uses energy for its own purposes. Only a fraction is wasted and is available to be harvested. Sunlight to grass. Less than 1% of the energy is stored in the grass in a way available to a cow. Grass to milk. Same thing. Only 1/10,000th of the sunlight is available to you from the milk when you eat the cheese made from it. only a fraction of that energy is available in your waste. Yet the parts of the system from farm to fork can be made self sustaining with careful attention to detail and changing a few things.

In 1976 your tax dollars were hard at work figuring this out as NASA scientist Harry Jebens gathered research data to figure out how to feed a person actually 10,000 persons in a city in space. Here we had to process everything to avoid a buildup of waste and eliminate the need to import costly items from Earth. This was the first practical application of another legendary NASA scientist D R Criswell of their concept of demandite!
NASA Technical Reports Server (NTRS) https://ntrs.nasa.gov/search.jsp?R=19780044024
Here a society eliminates ALL waste recycling it all and reducing its demand for primary materials including primary energy.

10. ISOTOPIC SIGNATURES IN THE TISSUES OF MYTILUS GALLOPROVINCIALIS AND ULVA LATUCA AS BIO-INDICATORS FOR ASSESSING THE IMPACT OF DISCHARGED SEWAGE EFFLUENT ON THE NEARSHORE COASTAL MARINE ECOSYSTEM ALONG OTAGO PENINSULA, NEW ZEALAND

Authors: O.A. Babaranti1, S. Horn2, R.D. Frew1 and R.V. Hale1

Authors affiliations: 1. Department of Chemistry, University of Otago, Dunedin, New Zealand
2. Department of Conservation, New Zealand

Sewage, waste organic matter from domestic and municipal wastewater causes increased secondary productivity, eutrophication and trace metal contamination, reduced oxygen levels and biodiversity which can lead to ecological disturbances in the natural aquatic ecosystem. Inadequately treated sewage effluent discharged into the marine area, poses environmental and health hazards to the resident biota in adjacent coastal areas. In assessing the impact of sewage derived organic matter on the nearshore marine ecosystem, the disparities in the carbon and nitrogen isotopic signatures in the tissues of endmember organism become useful bio-indicators.

The contrast of endmember mussel tissues appraised exhibited in our study had a trophic enrichment factor of 3 ‰ (δ15N) and 1 ‰ (δ13C) when compared to the marine particulate organic matter suggestive of dietary change from sewage effluent. Suspended particulate organic matter collected from riverine and estuarine sources revealed other possible contributory nitrogen sources from pastoral farming, organic manure and inorganic fertilisers, nitrification of ammonium from septic tanks and animal organic waste residues.

11. THE HIDDEN VALUE IN PRIMARY INDUSTRY WASTES

Authors: Dr. Chris Hearn

Author Affiliations: ADI System /BPO Dunedin

Wastewater treatment and disposal is usually seen as an imposed cost, yet handled in the right way wastewater can be a source of energy, nutrients and reusable water. Here we present full scale industrial wastewater treatment plant case studies where electricity, process heat and high-quality water are produced.
The primary industry in New Zealand is coming under an increasing pressure to improve the efficiency of wastewater treatment. For example, the dairy sector, which is the largest manufacturing sector in New Zealand, consumes considerable amounts of energy and fresh water. Anaerobic treatment of the primary industry wastewater can generate results in the production of biogas, which provides a renewable source of energy. Secondary aerobic treatment generates effluent that is clean enough to be discharged into the environment or can be reused in the factory process. The combination of anaerobic and aerobic offers the best effluent quality for the lowest energy consumption.

12. GROUNDS FOR SUSTAINABILITY: ENERGY FROM SPENT COFFEE GROUNDS

Authors: Dr Alan R Hayman

Author Affiliations : Chemistry Department, University of Otago

Our goal is to efficiently produce fuel pellets/briquettes from spent coffee grounds (SCGs). The utilisation of two organic waste products, SCGs and waste cooking oil, provides the necessary feed-stock to produce a solid fuel with a calorific performance similar to a wood/coal mix. International studies have shown that SCG waste can effectively be converted to fuel pellets that have a higher calorific content than the equivalent wood pellets. However, this typically requires extensive processing with significant inputs of energy and labour. We aim to develop a simple streamlined process that is more practicable, energy efficient and cost effective. And in doing, demonstrate the efficacies of waste minimisation and energy sustainability to small hospitality businesses.

SCG's have been collected from a local café and dried to produce feed material of varying moisture content. Spent cooking oil from deep-fryers has also been collected. Our initial goal is to determine the optimal composition of feed material ie SCG moisture content, and the optimal blend of SCG's and cooking oil. This optimisation is imperative not only for the calorific properties but also the physical characteristics of the fuel. Key physical characteristics include; the efficacy of the mechanical processing ie compaction into a pellet or briquette, the density, the hardiness/brittleness of the sold fuel produced, and the ability of the solid fuel to re-absorb moisture.

13. KEYNOTE: NZ AGRICULTURE AND THE ENVIRONMENT: DIVERGING PATHWAYS TO A SUSTAINABLE FUTURE.

Authors: Professor Hugh Campbell

Author Affiliations: University of Otago

Since the major period of reforms which significantly transformed the policy and economic framework for farming in the 1980s, different export sectors have taken widely diverging pathways in relation to issues of the environment and sustainability. Some export sectors have followed market demand for 'green' products and undertaken significant transformation of production systems, governance and auditing of environmental performance, and branding propositions in the global market. The 20th anniversary of Zespri kiwifruit in 2016 gave an opportunity to reflect on this kind of strategy for one of our highest value export products. In contrast, the NZ:China Free Trade Agreement opened up a unique pathway to a new market for basic dairy products. The resulting dairy boom revealed some key limitations of our resource planning framework and laid the basis for a major crisis of social legitimacy for pastoral farming in New Zealand. Between dairy and kiwifruit we see two drastically different models for a sustainable future for NZ.

14. ANAEROBIC CO-DIGESTION OF DEFATTED HYDROLYZED MEAT PROCESSING DISSOLVED AIR FLOTATION SLUDGE AND MEAT PROCESSING STOCKYARD WASTE

Authors: Oseweuba Valentine Okoro1, Zhifa Sun1, John Birch2*

Authors affiliations: [1]Department of Physics, University of Otago, PO Box 56, Dunedin, New Zealand [2]Department of Food Science, University of Otago, PO Box 56, Dunedin, New Zealand
**Corresponding Author: Zhifa Sun, Ph: 64 3 4797812, Email: zhifa.sun@otago.ac.nz*

In line with global efforts to motivate paradigm transitions from waste disposal to resource recovery, this research examines the anaerobic co-digestion of high moisture hydrolysed dissolved air flotation sludge and stockyard waste obtained from animal pens. The co-digestion of these waste streams was investigated since it serves to increase the substrate concentration and also introduces useful synergizing effects. Experimental investigations showed that stockyard waste and hydrolysed dissolved air flotation sludge residue co-digested in a mass ratio of 4:1, on a volatile solid basis, resulted in a maximum biomethane yield of 264 mL/g-VS and a maximum co-digestion index of 1.78. The biomethane yield from the mono-digestion of single substrates was shown to be poorer than the biomethane yield from the co-digestion of both substrates, affirming the significance of synergizing effects.

The integration of a secondary hydrothermal liquefaction processing of biomethane digestate residue as a pathway for value addition to the digestate was also explored. Theoretical determination of the yield of useful products obtainable from the hydrothermal processing of the digestate was initially undertaken. The yields of biochar, biocrude and aqueous-phase product are favorable, in comparison with reported results from the literature. Our results therefore provide a compelling basis for future experimental investigations into the viability of an integrated co-digestion and hydrothermal biomass conversion system.

15. FINANCIAL MANAGEMENT OF DROUGHT UNDER DIFFERENT PRODUCTION INTENSITY SYSTEMS: INSIGHTS FROM NEW ZEALAND DAIRY FARMERS

Authors: Johnston, A., Whiting, R.H and Diaz-Rainey, I.*

*Authors affiliations: Department of Accountancy and Finance, University of Otago *Formerly BComHons student, now at McIntyre Dick & Partners, Invercargill*

Climate change is likely to make the management of drought an issue of increasing importance. This study examines the relationship between dairy farm production intensity systems and the financial management of drought. We interview fifteen dairy farmers (seven from Waikato and eight from South Otago – Southland) from a range of production systems to discuss their management strategies that help reduce the financial impact of drought. Additionally, published statistical data from DairyNZ yearly economic surveys is analysed.
We develop a decision-making model which incorporates farmer attributes and risk perceptions and describes the range of options farmers use to mitigate the financial impact of drought. These options are influenced by various factors, most importantly the milk-solids payout. The higher likelihood of drought in the Waikato has contributed to farmers' decisions to intensify their farming systems to reduce its financial impact. On average, these higher intensity production systems are more profitable than lower intensity production systems, but are less flexible and face greater risk. Due to their high debt, asset structure and input costs, these production systems come under financial pressure during a drought, especially if combined with a low payout. However, we find that proactive planning by farmers can help to reduce the impacts of

drought. Whether this is enough to deal with more intense and frequent droughts as expected with climate change, remains to be seen.

16. GREEN FUEL GENERATION USING WASTE HEAT EXHAUSTED FROM MILK POWDER SPRAY DRYERS

*Authors: Madeleine Mark, Zhifa Sun**

*Authors affiliations: Department of Physics, University of Otago, PO Box 56, Dunedin, New Zealand *Corresponding Author: Zhifa Sun, Ph: 64 3 4797812, Email: zhifa.sun@otago.ac.nz*

Waste heat recovery from milk powder spray dryer exhausted humid air has proven challenging due to both economic and thermodynamic constraints. At a milk powder plant in New Zealand, a significant amount (89 GWh) of heat energy accompanying exhausted spray dryer air is lost to the environment, over the plant operating season (4,500 hours). This researech investigates the feasibility of storing this waste heat as chemical potential energy in solid chemicals via a thermochemical energy storage system, to be used for residential space heating.

The spray dryer exhausted air stream is very humid, carrying a large amount of water vapour evaporated from milk. In this research, a simple heat exchanger has been analysed to facilitate the transfer of heat from the spray dryer air stream to a fresh (less humid) environmental air stream. The heated fresh air stream is then used to drive the chemical reaction in the thermochemical energy storage reactor to produce solid chemicals storing heat energy. A thermodynamic model for the combined system of the heat exchanger and thermochemical energy storage reactor has been developed, to analyse the technical feasibility of the system. Our results indicate that the combined energy storage system is able to store 9.3 GWh of waste heat energy over the plant operating season, which can provide 2,400 homes with heating.

The cost, fuel consumption and resulting carbon emissions from the transportation of the thermochemical materials (containing the stored heat) to nearby towns has been initially investigated.

17. KEYNOTE: THE BIOECONOMY - AN UTOPIAN NECESSITY

Authors: Martin F. Hohmann-Marriott

Authors affiliations: Associate Professor Department of Biotechnology, Norwegian University of Science and Technology, NTNU

Our fossil fuel-based economy is changing Earth's climate. A bio-based economy has been proposed as a sustainable alternative. In my talk I will outline opportunities and limits of a future bioeconomy using an energy framework. Currently humans use around 15% of all biomass produced on Earth, and tapping further into this resource appears a futile preposition. Comparing the efficiency of biological and human-implemented approaches for energy conversion and carbon capture indicates that biomass should be prioritized as a food source, not as a source of energy.

18. ENERGY IN NEW ZEALAND'S FOOD SYSTEM

Author: Warren Fitzgerald

Author affiliation: Centre for Sustainability, University of Otago

Emissions from ruminant animals consistently receive the most attention when it comes to agricultures effects on the climate, but the entire food system, from paddock to plate, is maintained by intensive energy inputs, the majority of which originate from fossil fuels.
Since ratifying the Paris agreement, and its subsequent entry into force, New Zealand is now bound to reducing its greenhouse gas emissions in an attempt to limit global temperature rises to well below 2°C. If we are to have any hope of meeting these requirements, then agriculture will have to be included in any mitigation efforts.
Recognising the type of energy and its essential role in primary food production is fundamental to any efforts which aim to help decarbonise our agricultural system.
This presentation aims to visually represent the energy flows throughout primary food production, with emphasis on where and how non-renewable resources are consumed and the potential for alternatives.

19. FLEXIBLE ENERGY CONSUMPTION ON NZ FARMS

Authors: Jefferson Dew, Janet Stephenson, Sara Walton, Michael Jack

Authors Affiliations: Centre for Sustainability

Electricity demand in the agriculture sector is becoming a more significant component of New Zealand's electricity consumption. Irrigation in particular has been featured as contributor to fluctuations in demand, leading to some electricity networks observing a summer peak of similar magnitude to the traditional winter heating load and the recent rainy summer reducing turnover for retailers. Demand flexibility, altering the amount or time of energy consumption, has the potential to provide services across the electrical system, providing an alternative to peaking plants for generation and reducing infrastructure requirements in transmission and distribution.

The talk will focus on my PhD research, part of the National Science Challenge - Science for Technological Innovation, which involves looking at the social and technical barriers to farmer engagement with electrical demand flexibility to hopefully enable more efficient use of the electricity system. In order to understand the needs of the fields I am working in I have interviewed stakeholders from the farming and energy sectors, providing some contrasting viewpoints on the future of energy in agriculture. I will discuss some preliminary findings from these interviews and the refinement of my research questions from this.

20. KEYNOTE: CLEAR PRICE SIGNALS AND COOPERATION THROUGH 'CLIMATE TEAMS' ON THE PATH TOWARD LOW EMISSIONS

Authors: Suzi Kerr

Authors affiliations: Motu, Economic and Public Policy Research

Two critical challenges for an effective transition to low emissions in New Zealand are: providing a clear, more predictable signal for low-emission investment; and finding a way to help other countries move more rapidly on their own paths to low emissions, producing, at the same time, credible reductions that New Zealand can use to meet its targets under the Paris Agreement. Through domestic dialogue and international collaboration, Motu's Shaping New Zealand's Low Emissions Future programme has developed a model that addresses each of these issues.

21. ELECTRICITY FUTURES AND STOCK MARKET RESPONSE TO ELECTRICITY SECTOR MATERIAL DISCLOSURES

Authors: Ivan Diaz-Rainey[1,2], Xing Han[2], Greg Sise[3], Sam Aitken[2]

Authors affiliations: 1. OERC, 2. Department of Accountancy and Finance, University of Otago, 3. Energy Link Ltd., Dunedin

A material disclosure with sector-wide ramifications by an energy utility has the potential to impact its own stock price, that of its competitors, but also the price of spot electricity and electricity futures. We explore 66 such announcements in the New Zealand context given concerns that 'insiders' may be trading ahead of announcements and affecting market confidence. Using an event study methodology, we test for abnormal returns in the lead up the 66 public announcement that are derived from a unique dataset that categorises events as having either negative or positive sector wide impacts. When examining the electricity futures market we incorporate in our analysis electricity futures prices, volume and open interest. For the futures market we find an asymmetric response pattern for the positive and negative events during pre-

event window (-5,-2). More specifically, indicating possible information leakage prior to the news announcement, we find significant negative returns for negative events, while there is no significant market response for the positive events. We find evidence that during the positive or negative event days, the trading volume surged and open interests decreased dramatically (this interpretation was based on economic rather than statistical significance). For stock returns we find no evidence of any unusual market activities prior to, during, and after the events.

22. THE LEGAL CHALLENGES OF THE EMERGING ACTIVE ROLE OF ELECTRICITY CONSUMERS

Author: Daniela Aguilar Abaunza

Affiliations: University of Waikato.

The electricity sector is on the verge of significant change because of technological innovation, together with a distrust in conventional energy supplies and increasing awareness of climate change. This shift mainly involves a more active role for consumers, where they can both, generate and manage their energy and trade or store their energy surplus. New technologies and business patterns, such as distributed generation, smart grids, demand side management and energy storage offer a brilliant opportunity for making it a reality. This emerging model could lead to enormous benefits including enhancing energy security, mitigation and adaption to climate change, improved sustainability and efficiency, more economical and efficient energy supply service and a growth in customer benefits.

Nevertheless, the rise of more active electricity consumers, called by some scholars as “energy prosumers”, brings new challenges to the legal system underpinning traditional electricity supply which was established based on a clear distinction between consumer and producer. The emerging overlapping of roles creates new issues and questions for the current legal system that may result in it becoming obsolete. Therefore, the question of how to adapt the present legal system and/or the need to create a new one is now open for debate. The issues also include how to regulate innovation where the technological advances are occurring more rapidly than the regulation is evolving resulting in the current law becoming out dated. As a result, we do not know what new legislation is needed or what the role of law should be.

23. THE 2017 DRY PERIOD

Authors: Greg Sise

Authors Affiliations: Energy Link Ltd., Dunedin, New Zealand

2017 provided the electricity market with a reminder of what happens when hydrological inflows into the hydro storage lakes fall well below normal levels for a sustained period, and storage falls. This talk will review the hydrology, how the physical assets performed, and how the market managed the event. The assets considered will be those belonging to key generating companies and the HVDC link which connects the two islands, and which has recently been upgraded to provide lower cost transport of energy between the islands.

24. LAW, POLICY AND RENEWABLE ENERGY

Authors: Will Anglin,

Authors Affiliations: Barrister, Counsel for Blueskin Energy Limited

The efforts to develop a local renewable electricity supply via wind generation at Blueskin Bay date from an idea first expressed in 2006. In September 2017, an Environment Court ruling declined consent. Should it be this hard for citizens to do their part in mitigating climate change and democratizing the electricity sector? In this presentation we look at the Environment Court case with its drama, and the place of the National Policy Statement on Renewable Electricity Generation and its role. Typically people do not initially understand the full extent of long term benefits these projects can bring to the local community, until there is a precedent, and then they tend to attach lower weights to concerns around variability, visual impact and bird-strikes. This project would have set that precedent. So what led to the declining of consent? What options remain for community wind? Elsewhere in the world, citizen ownership of renewable electricity assets is commonplace. What will need to change for it to become common place in New Zealand?

25. KEYNOTE: INCEES: AN INTERNATIONAL COLLABORATORY FOR ENERGY, ENVIRONMENT AND SUSTAINABILITY AT WASHINGTON UNIVERSITY

Authors: Professor Himadri B. Pakrasi,

Authors affiliations: Director, International Center for Energy, Environment and Sustainability (InCEES) Washington University

The International Center for Energy, Environment and Sustainability (InCEES) connects the Washington University community as the lead institutional hub for research, education and practice in developing improved solutions for energy, environment and sustainability grand challenges critical to the well-being of our society and our planet. Energy and environmental challenges should be of the highest priority in the 21st century. Considering the magnitude of the potential adversities to the world, every major research university has the professional and ethical responsibility to educate students, inform the global citizenry and collaborate to develop

and implement solutions to such challenges. It is critical that universities work together to identify solutions and systems that provide access to energy without adversely affecting the environment. Advances in science and engineering will be needed to make progress, but business, urban and architectural design, social sciences, the humanities, law and medicine are all essential to the work without boundaries required to achieve the best possible outcome for the global community.

At Washington University, the hub of InCEES includes seven signature partnerships; a robust internal funding program; a growing cadre of interdisciplinary researchers; a named lecture series to engage the broader university community; and a curriculum support focus that has helped engage new instructors, develop new courses and provide experiential opportunities for students. InCEES also has significant global impact through a network of partners, field sites and participation in international climate change meetings. Some of the current activities at InCEES will be discussed during this presentation.

26. KEYNOTE: IMPLEMENTING AN ENERGY RESEARCH STRATEGY FOR NZ

Authors: Simon Arnold

Authors affiliations: Chief Executive, National Energy Research Institute

Mission oriented applied directed research is an important tool to help a country manage the risks and opportunities from an uncertain future. The NZ energy sector faces just such uncertainty, facing significant technology, environmental and social pressures. NERI has developed an energy research strategy to help it respond. This talk will outline the main themes, the key research capabilities indicated, and the steps being taken with the research community, industry associations and the Government to implement the required investments.

27. OERC ENERGY LIVING LAB

Authors: Jane Wilcox[1], Michael Jack[2], Mark Mason [3], Hans Pietsch[3] , David Eyers[4]

Authors affiliations: [1]OERC, [2]Department of Physics, [3]Property Services, [4]Computer Science, University of Otago

An overview of the OERC Energy Living Lab, its projects and lessons learnt.

28. RENEWABLE HYDROGEN FUEL PRODUCTION USING EARTH-ABUNDANT MOLYBDENUM DISULFIDE CATALYSTS EARTH-ABUNDANT MOLYBDENUM DISULFIDE CATALYSTS

Authors: Charlie Ruffman, Anna Garden

Authors affiliations: Department of Chemistry, University of Otago

Over the next 50 years the world faces a major challenge in reducing its consumption of fossil fuels to reach sustainable emission targets.1 One solution is a shift towards a hydrogen economy, where H2 is used to store, transport, and provide energy. Unlike fossil fuels, no accessible reservoir of H2 exists on Earth, therefore it must first be produced. This can be accomplished via electrocatalytic splitting of H2O into protons (H+), electrons (e-) and oxygen (O2), and the subsequent reduction of H+ in the hydrogen evolution reaction.

The most efficient catalyst for hydrogen evolution is Pt, however this is scarce and therefore uneconomical for H2 production on an industrial scale. As a result, there has been significant interest in designing alternative catalysts from abundant and inexpensive materials. 2 Nanoscale molybdenum disulphide (MoS2) surfaces are cheap to synthesise and have shown catalytic activity towards H2 evolution.3 However, the mechanism for hydrogen evolution on MoS2 is not yet well understood, and the catalyst must be optimised to perform as well as Pt. Specifically, it remains unclear how the rate of reaction is affected by the choice of catalyst support and by the applied voltage.
This presentation will discuss results from first-principals computational chemistry calculations on how the rate of hydrogen evolution on MoS2 can be tuned by a catalyst support and the applied voltage. The results allow a more comprehensive understanding of the hydrogen evolution reaction on MoS2 and contribute to the optimisation of this key process in sustainability.

29. PRODUCING HYDROGEN FROM WATER AND SUNLIGHT USING MOLECULAR COBALT CATALYSTS

Authors: Ross Hogue (1), Olivier Schott (2), Garry Hanan (2) and Sally Brooker (1)

Authors affiliations: (1) Department of Chemistry and MacDiarmid Institute for Advanced Materials and Nanotechnology, University of Otago, New Zealand
(2) Département de Chimie, Université de Montréal, Canada

Hydrogen is widely seen as the solution to securing a future energy supply which is renewable and environmentally sustainable. As a combustion fuel, hydrogen possesses the highest energy output relative to mass, and the waste product is water. However, this clean fuel is not present on Earth in free molecular form. Using catalyst materials which can harness sunlight to drive the

splitting of water into molecular hydrogen and oxygen is the ultimate renewable source of clean fuel.
Over the last decade cobalt molecular materials have proved to be efficient catalysts for half of the water splitting reaction: proton reduction (H+) to molecular hydrogen (H2). Cobalt has an advantage over established rare-earth catalyst materials in that it is cheaper, safer, and more abundant. Here we present the results of our initial screening of several new molecular cobalt materials for photocatalytic hydrogen evolution as we look to add diversity to this relatively young area of research. We will also explore structure-activity relationships to establish key molecular design features which will aid in the development of the next generation of hydrogen evolving cobalt materials.

30. HOUSEHOLD ELECTRICAL PEAK DEMAND CHARACTERIZATION: TOWARDS MORE EFFECTIVE DEMAND SIDE MANAGEMENT

Authors: Imran Khan[1], Janet Stephenson[1] Michael Jack[2]

Authors affiliations: [1]Centre for Sustainability, [2]Department of Physics, University of Otago

The electricity generation and transmission infrastructure of a country needs to be able to provide for the highest level of electricity demand from consumers. This is known as peak demand and its infrequent occurrence results in expensive infrastructure being underutilized most of the time. Peaks occur on a daily basis in most nations, driven predominantly by variability in demand in the residential sector. A more efficient and stable grid with less unused capacity can be achieved if peaks are smoothed, and this is usually achieved by demand side management (DSM) tools (e.g. pricing, ripple control). However, traditional DSM is applied to every household (HH) irrespective of the households' electricity demand profile. It may be more effective to identify the households that are particularly 'peaky' (i.e. have high electrical demand during peak hours), and this work sets out to develop a method to achieve this. Peak demand characterization was conducted using data on HH characteristics and time use patterns collected from 22 and 65 HHs in New Zealand and Bangladesh, respectively. Peak demand characterization involves (1) identification of the 'peaky' HHs by assessing their peak time demand; (2) categorising the factors which contribute to demand during peak hours; and (3) identifying significant statistical correlations among those different peak drivers or factors. Household electrical peak demand characterization may assist the electricity sector and policy makers in developing more effective DSM methods.

31. THERMOCHEMICAL MATERIALS FOR THERMOCHEMICAL HEAT STORAGE SYSTEMS

Authors: S. Cem Akcaoglu [1,2,] Zhifa Sun [1], Stephen Moratti [2.]

Authors affiliations: [1]Department of Physics, University of Otago, PO Box 56, Dunedin, New Zealand [2]Department of Chemistry, University of Otago, PO Box 56, Dunedin, New Zealand
**Corresponding Author: Zhifa Sun, Ph: 64 3 4797812, Email: zhifa.sun@otago.ac.nz*

Seasonal thermochemical solar-heat storage systems are capable of multi-cyclic operations for more than 10 years and able to significantly reduce greenhouse gas emissions and energy consumption of residential space heating. Thermochemical materials must be environmental friendly to conform to residential applications and must have high reactivity for reversible thermochemical reactions and high conductivity and diffusivity for heat and mass transfer. To improve the thermochemical properties of pure salt hydrates, in this research, nontoxic salt hydrates, strontium bromide and magnesium sulphate, which have good thermal stability and high energy densities of ?2.0 GJ/m3, were mixed with expanded natural graphite and activated carbon, to form thermochemical composites. More than 40 composites were prepared in our lab and were characterized using the thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) techniques. Hydration (at 20°C) and dehydration (at 90°C) cyclic tests of these composites were conducted to investigate their surface morphology and thermal features (such as weight losses and heat release) during the energy discharging process. Pellet composites were produced in our lab and were tested in three hydration and dehydration cycles. The pellet magnesium sulphate-activated carbon composite samples achieved a high energy intensity up to 1672 J/g (approximately 1.55 GJ/m3) with a stable thermal performance. However, pellet composites showed geometric deformation and during dehydration the salt hydrate crystals leaked from the pellet composites at 90°C. Further research is currently carried out to solve these problems.

32. RISK-NEUTRAL MOMENTS AND CUMULANTS IN THE CRUDE OIL MARKET

Authors: Xinfeng Ruan and Jin E. Zhang

Authors affiliations: Department of Accountancy and Finance, Otago Business School, University of Otago

In this paper, we provide a comprehensive study on the higher-order moments and cumulants in the crude oil market, implied by options written on the United States Oil Fund (USO). We find strong evidence of their return predictability on USO excess returns. For example, the monthly adjusted R2 of the innovations in the volatility and the third cumulant are around 11%. In addition, we also find some evidence of their option return predictability by considering two

different types of USO option returns. Finally, after sorting portfolios for the selected stocks directly related to crude oil, based on given moment and cumulant risk factors, we find a significantly positive return of the fourth cumulant portfolio in the oil industry, around 2% per month in average (24% per annum) during our sample period from 09 May 2007 to 29 April 2016.

Presentations will be available on the OERC website shortly after the Symposium at:
http://www.otago.ac.nz/oerc/symposia/

Find out more about OERC at: http://www.otago.ac.nz/oerc/

Watch our 2017 OERC Seminars on our YouTube channel:
https://www.youtube.com/channel/UC9K_VzVKUSJr9FC2WSL9CYQ/videos

Follow us on twitter: https://twitter.com/OERC_at_Otago

For any further enquiries please contact Jane Wilcox at oercadmin@otago.ac.nz