17th Otago Energy Research Centre Symposium 2023

Abstracts Booklet

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND
SAPERE AUDE

OTAGO ENERGY RESEARCH CENTRE

Day — 1: Energy Wellbeing Consortium

Keynote:

Energy Wellbeing Session 1:

Poster Session:

Energy Wellbeing Session 2:

Multidisciplinary Energy Research:

Day — 2: Energy Research Agendas

Keynote:

Keynote:

Regional Transitions:

National Opportunities:

New Technologies:

A Sustainable Energy Transition for the United Kingdom – Understanding Distributional Impacts of Energy Policy

Ian Preston[1]

[1]Centre for Sustainable Energy, UK

Day 1 Keynote

Bio: I have 22 years of experience in sustainable energy and fuel poverty. I am part of the CSE's Senior Leadership Team and direct the Household Energy Services (HES) team. My team of fifty staff delivers projects that support people to access affordable warmth and make their homes low carbon and liveable. The team has an annual turnover that's over two million pounds. As Director I oversee award winning projects including Warmer Homes Advice and Money (WHAM), Futureproof, Tenant Energy Advice and the South West Power Up Hub for Western Power Distribution. I am a leading expert on low carbon retrofit, fuel poverty and energy justice, with particular focus on the distributional impacts of energy policy on energy expenditure. I play a key role in CSE's policy work and was a member of BEIS's Fuel Poverty Methodology Group when it existed. I have a detailed understanding of Government fuel poverty policy and underpinning statistics and am able to interpret the potential impacts of policy from the perspective of Government, businesses and householders, including the strategic implications for the delivery of policies at a commercial level. I have recently led the development of CSE's PAS 2035 service provision. Following the successful completion of CSE's Futureproof pilot, I coordinated the necessary training of staff, review of internal systems and implementation of new software tools to support this work. CSE is now able to offer retrofit plans to fee paying householders and recently won the Bristol City Council tender for their Retrofit Assessment and Coordination work.

Are the majority of energy users really "Hard-to-Reach" or are we not trying hard enough to reach them?

Authors: Dr Sea Rotmann[1,2]

[1]SEA - Sustainable Energy Advice Ltd

[2]Hard-to-Reach Energy Users Task by Users TCP by IEA

The Hard-to-Reach (HTR) Energy Users Task by the Users TCP by IEA, has delved deeply into HTR energy users, and what engagement strategies have worked to reach them in case studies around the world, and via co-designed field research pilots in Aotearoa NZ, Canada, and the United States. Main findings were that:

1. Their numbers were significantly greater than we hypothesised (Rotmann et al, 2020).
2. They are an extremely diverse cohort, in both residential and commercial sectors, and being low-income does not necessarily make them HTR (ibid).
3. Top-down designed behaviour change interventions aimed at poorly-characterised energy users have several methodological failings, including a lack of participatory co-design processes (see Karlin et al, 2021; 2022; and Mundaca et al, 2023).
4. End user needs and their lived experiences are often poorly understood by intervention designers in government, industry and research sectors, who generally operate from Eurocentric worldviews, privileges and biases.
5. Involvement of community middle actors, gatekeepers and navigators is crucial but extremely hard, as they are also often HTR, overworked and undervalued, and suffer from similar levels of distrust in well-meaning intentions of "experts" when it comes to how we acknowledge them, and their communities' data, stories, and suffering.

In short, it is not marginalised communities who are hard-to-reach, but us, who are not engaging them in ways that suit their needs, rather than ours. By focusing on fixing misperceived symptoms rather than underlying structural and systemic causes of energy injustice, we will fail to achieve a just energy transition for all.

Evaluating energy hardship interventions: from frameworks to measures

Authors: Janet Stephenson[1]

[1]Centre for Sustainability, University of Otago

Across Aotearoa, many groups, organisations and agencies are working to improve household energy wellbeing. They take a variety of approaches, from physical changes such as insulation, to efficiency education and budgeting advice and much more. In a sense, there is a huge national experiment going on with different forms of intervention for the same outcome – energy wellbeing – but there is no way to compare between them. How do we know if interventions to improve energy wellbeing have made a difference? How do we know if one form of intervention is more effective than another? To answer questions like these, we need comparable ways of evaluating the impacts of an intervention.

Currently we don't do this well. The place to start is a sound understanding of the many factors involved in energy wellbeing. I discuss a range of already-existing frameworks for aspects of energy hardship. I compare frameworks that identify direct contributors to energy hardship, those that identify causal factors in the wider context, and those that focus on the outcomes of energy hardship. Drawing from the frameworks and evaluation work by others, I propose some low-cost evaluation measures that align with the frameworks and could be used across all types of intervention to evaluate within-project success as well as enable comparisons between projects.

This presentation represents my perspectives but draws from many fruitful discussions within our 'frameworks' group of the Energy Wellbeing Evaluation Consortium and inspirational input from other members of EWEC.

Life lessons from Community-based energy research

Authors: Phoebe Taptiklis[1] and Rangimaria Aperahama[1]

[1]Motu Economic and Public Policy Research

Phoebe led data collection for the Warmer Kiwis Study, completed in 2022, and is now leading the quantitative evaluation of the Public and Māori Housing Renewable Energy Fund Evaluation.

This presentation is a reflection on lessons learned from experience in the field. The hope is this can help others with planning and developing realistic expectations in data collection for energy efficiency and housing related research.

Issues we will discuss include:

- Accessing electricity records through the Electricity Authority: how it works, hoops to be jumped through, what kind of data quality to expect.
- Engagement and communication in multi-level research partnerships: Energy efficiency programmes are often community based. This can be great, but can also mean additional work.
- Monitoring equipment and data collection hacks (and dramas): Wifi enabled or standard data logging: which is better to use? Electronic survey tools. Field visit versus remote data collection – phone or internet. We will also present some preliminary results using EA data before and after solar installation to demonstrate what all that effort can get you.

Being a force for good, powering a cleaner brighter future with our communities

Authors: Hinerangi Pere[1,2]

[1]Ngati Raukawa ki Wharepuhunga, Ngati Mahanga, Waikato Tainui, Ngati Kahungungu ki Heretaunga, Ngai te Rangi, Nga Puhi

[2]Orion

To enable decarbonization and electrification an unprecedented $22billion needs to be spent on distribution infrastructure alone in the 2020s. This will see electricity bills rise, but for those who can decarbonize total energy spending should fall. This combined with the recent lessons from Cyclone Gabrielle on the importance of secure community hubs, highlights the importance of involving the community in decarbonization.

Orion has been building community relationships and exploring different community energy models.

Orion, is on a journey towards becoming a force for good in the race to achieve net-zero for our regions. At the core of the transition is a commitment to foster conciliation between our operations and the wellbeing of the communities we serve, in response to this, Orion Community Energy Services was created.

CES is Orion's investment in understanding and supporting our communities and their energy aspirations for the future. Thus, enabling communities to not only dream, but to actively engage in the journey of a sustainable energy future and how they can equitably access the network and infrastructure to support their energy aspirations

As Orion CES continues to evolve and respond to the needs of our communities, we recognize that we are on a learning journey, walking alongside our communities, mutually gaining knowledge and acknowledging that our communities are the true experts in this endeavor.

The Role of (H_2-Diesel) Dual Fuel Vehicles in Accelerating the Uptake of H_2 Fuel-Cell Heavy Vehicles in New Zealand

Authors: Al-Hasan Ali Abdulwahid[1], Jonathan Leaver[2], Michel Jack[1]

[1]Department of Physics, University of Otago

[2]School of Civil and Environmental Engineering, Te Pukenga

Despite heavy vehicles only constituting 4% of the total fleet in NZ, they produce 25% of the country's road transport emissions. Vehicles using hydrogen from renewable resources, such as hydrogen fuel cell vehicles, are potential low-carbon alternatives. However, their widespread adoption faces challenges due to a lack of refuelling stations and high capital costs. This study investigates the role of hydrogen-diesel dual fuel heavy vehicles (DFVs) in accelerating the uptake of hydrogen-fuel-cell heavy vehicles in NZ, using a system-dynamics model (UniSyD NZ). The model's decision-making dynamics in adopting new vehicles over time is based on a Nested Multinomial Logit (NMNL) model, considering attributes like fuel availability and vehicle capital cost in consumer vehicle choice. Due to the lower capital cost of DFVs compared to hydrogen fuel-cell vehicles and the flexibility to operate on 100% diesel when hydrogen is unavailable, DFVs can solve both the lack of refuelling stations and the high vehicle's capital cost issues which face all alternative fuel vehicles. The study's simulation reveals that the temporary use of DFVs in the early stages significantly enhances fuel availability for all types of hydrogen vehicles, accelerating the timeline to achieve the minimum fuel availability required for widespread adoption.

Examination of Mechanical Durability of Aluminium Topographically Modified for Energy Applications

Authors: Kirill Misiiuk[1], Sam Lowrey[1], Richard Blaikie[1], Andrew Sommers[2]

[1]University of Otago

[2]Miami University

Nature has evolved several impressive water management solutions. The most cited and well-known example is the super water-repellent lotus leaf. Behind this "magic" property are random microscale bumps with superimposed nanoscale hairs covered in wax. However, for industrial applications, everything is made of metals or at least has a metallic coverage. To make it water-repellent it is usually proposed to hide the metal surface under a water-repellent coating. From the energy efficiency point of view, such surfaces (1) promote dropwise condensation over film-wise, improving water droplet removal, which is beneficial for heat exchangers, and (2) promote delay (or elimination) of ice-/frost-formation under extreme weather conditions, which may be beneficial for wind turbine blades. Accepting the challenge, topographical modifications of metals were investigated by our team proposing solutions to make coating-less superhydrophobic metallic surfaces. Such surfaces could be made on metal via one-step industrial methods in a very controllable way (thus, allowing them to be integrated into a manufacturing process potentially reducing the overall cost). However, similar to coatings, the metallic structures could be vulnerable to harsh environmental conditions (for example, wind turbine blades are exposed to impacting droplets and solid particles carried by wind). We will present a methodology of durability evaluation based on a market-available device and preliminary results of comparison with non-modified metals, as well as problems among all published methods prior to this study.

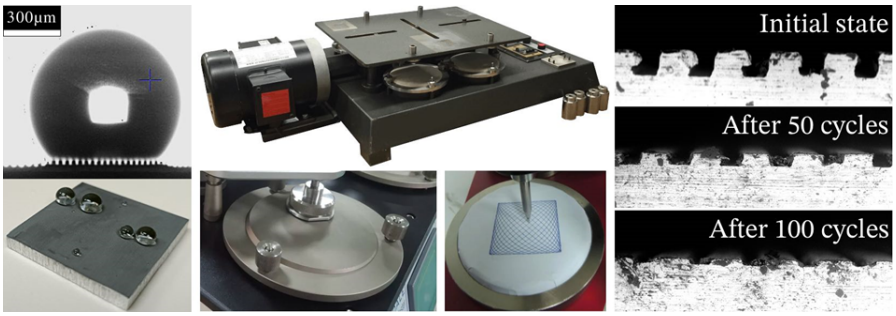

Fig. 1. (left) superhydrophobic topographically modified aluminium; (centre) Martindale abrasion machine with the motion pattern; (right) degradation of the microstructure.

Climate science inspires students to drive down school-run carbon dioxide emissions

Authors: Celia Wells[1]

[1]GNS Science

Cutting-edge climate science has enabled Meadowbank School students to see the invisible – how their transport choices can make a direct difference to the CO2 emissions in their local area.

An inconspicuous shoe box-sized atmospheric sensor has been measuring the CO2 and CO concentration outside the school, installed by GNS Science as part of wider work to understand urban emissions and support climate mitigation at a local level.

The data gathered showed spikes in CO2 and CO concentration in the morning that are much greater during term time compared to school holidays, indicating the daily school-run is the culprit.

Concerned by the data, the Year 6 Enviro leader students decided to take action, organising a two-week schoolwide festival of active transport activities to lower carbon emissions, including a 'Glam your Wheels' day for scooters and bikes, 'Wear What Ya Want Walking Wednesday', and a 'Feel Good Friday' to encourage groups of kids to walk to school together.

"It shocked us seeing the spike in the morning during drop off time and we knew we could take action to reduce this, but we needed to get the whole community involved - we couldn't do it alone," said Ava Moody, Meadowbank Year 6 Enviro Leader student.

GNS Science socio-economic policy specialist, Celia Wells has been working with the students throughout the initiative, and said that by bringing the specialist equipment to the school they've been able to help the students realise that small personal actions can make a difference.

"Because CO2 emissions are invisible, it is difficult to connect changes in our own behaviour to changes in the atmosphere."

Electrocatalytic HER study of monometallic and mixed-metal pyridazine linked cryptates

Authors: Varinder Singh[1] and Prof. Sally Brooker[1]

[1]Department of Chemistry, University of Otago

The conversion of energy-poor feedstock such as water to energy rich molecules like H2, driven by renewable energy, has emerged as a promising pathway for producing future fuels. As these conversions are energy intensive, catalysts are required for effective conversion of such feedstock into eco-fuels.

This presentation will discuss the key findings and methods used to investigate mixed metal pyridazine linked cryptates[1-4] as potential catalysts for the hydrogen evolution reaction (HER). Electro-catalytic HER testing was carried out on mononuclear, $[ML^{i}](BF_4)_2$, M = Fe, Cu, and heterobinuclear cryptates, $[M^{II}Cu^{I}L^{i}](BF_4)$, M = Fe, Co, Cu, and Zn in acetonitrile vs 0.01 M $Ag/AgNO_3$, glassy carbon working electrode. The heterobinuclear cryptates formed heterogeneous deposits on the working electrode surface and showed ongoing modest activity over 2 hours of controlled potential electrolysis (CPE) at -1.6 V with acetic acid as proton source.

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Opportunities for green hybrid generators serving remote NZ

Authors: Bill Currie[1], Neil Fernandes[1]

[1]Powerhouse Wind Ltd, Dunedin

Imbalances in the energy trilemma are keenly felt at the edge of grid. Many parts of NZ are still serviced by sparse and tenuous energy infrastructure and these vulnerabilities were emphatically exposed in 2023:

1. Rural communities in the north of Aotearoa experienced first-hand the susceptibility of the grid to the cyclones birthed by rapidly changing climate patterns. With roads also badly damaged even diesel resupply could not be relied upon, leaving communities isolated.

2. The Energy Networks Association warned that the industry will have to upgrade infrastructure to cater for EVs amongst other demands and urban upgrades will likely be prioritised over rural. Already lines companies are reluctant to make new rural connections to lines already at capacity.

On-site renewable generators can provide high quality green electricity and reduce the risk of extreme weather events to remote communities and critical equipment. Powerhouse Wind Ltd (PHW) is intent on tackling the energy trilemma in rural Aotearoa by meeting domestic and small commercial energy needs with our modular hybrid energy generator. PowerCrate® increases renewable energy security by harvesting from wind and solar energy.

Our poster highlights progress at PHW and invites discussion on the technical and socio-technical opportunities in developing this architectural innovation for the future - a modular turnkey system is an ideal platform for implementing autonomous holistic solutions for improving off-grid customer experience.

Regional and seasonal breakdown of residential space heating demand in New Zealand

Authors: Hannah Konings[1]

[1]University of Otago

A regional and seasonal breakdown of residential space heating demand was developed, that uses a range of data sources available in New Zealand. This includes census data on the number of dwellings per territorial authority used to estimate the total regional floor area, average characteristics of a house built to the New Zealand building code, environmental temperatures to calculate heating degree days to account for climatic differences, and census data on the number of heat devices used to breakdown space heating demand and calculate regional space heating greenhouse gas emissions.

This method improved upon a population-only breakdown method, which overestimates Auckland space heating demand by 200% and underestimates Christchurch and Dunedin space heating demand by almost 50%. The seasonal breakdown showed an average of three times the space heating demand during winter months compared to the shoulder seasons. Emission breakdowns identify regions where emission reduction efforts could have the largest effects. These results aim to inform future policy and space heating efficiency and emission improvement decisions to better focus efforts for the largest impact.

Long-Term Strategic Energy Planning

Authors: Fatemeh Salmanpour[1], Hossein Yousefi[1], Mehdi Ehsan[2]

[1]Department of New Sciences and Technologies, University of Tehran

[2]Department of Electrical Engineering, Sharif University of Technology

There are different strategies to make an energy system more sustainable. Due to the high potential of REs in Iran, most of the recent studies has focused on REs for improving the energy system. REs are not cost effective in Iran yet, while, making changes in the structure of energy system under a long-term energy plan could offer a practical solution. In this article, energy system planning by 2050 has been conducted for the case of Iran. The main goal of this study is to provide a practical solution that can reduce the emission and cost, in addition of meeting the demands of different sectors including electricity, household, transportation, and industry. In this regard, five scenarios are designed and analyzed with focus on the share of REs, the efficiency of power plants, and the capacity of combined cycle power plants. The results of the cost analysis show that applying the Integrated scenario of REs and combined cycles would be effective in the reduction of total annual cost, CO2 emissions, and fossil fuel consumption. The average saved cost by integrated scenario is about $8.7 billion over 30 years compared to the BAU. Also, the reduce in the consumption of fossil fuels and CO2 emission is 294.74 TeraWatt hours and 65 million tons of CO2, respectively.

Good data on existing homes matters: The Residential Efficiency Scorecard

Authors: David Craven[1]

[1]Department of Energy Environment and Climate Action, and all Australian governments

We know the power of quality data, and how it is crucial in supporting the energy transition for existing homes. This presentation demonstrates the ways in which quality data, as collected by Scorecard assessors, supports research, policy and householder outcomes.

The national Residential Efficiency Scorecard is Australia's only energy performance rating and advice program for existing homes. Scorecard home assessments are delivered by trained and accredited assessors using a government-supported software tool, with all data held on a privacy-protected database. Due to the collection approach, Scorecard has the only quality dataset of energy performance in existing homes across Australia. Scorecard home ratings are comparable and repeatable, and cover: cost, carbon emissions, main household energy use and generation, performance in extremes of heat and cold, and targeted upgrade opportunities.

Consumer surveys found 94% of households take action after a Scorecard assessment. The Energy Savvy Upgrades program has shown the benefits that can be delivered by these trusted Scorecard assessments and assessors. This is the first program in Australia to show landlords will invest in upgrades if the program design is strong. Scorecard is also being used in a range of other programs, including the Victorian Energy Upgrades, a legislated energy retailer certificate program. Scorecard is a collaboration of all Australian governments, with opportunities for New Zealand to become involved.

Winter inside social homes

Authors: Tom Kane[1]

[1]Kāinga Ora

Kāinga Ora houses over 180,000 people in around 70,000 homes and is currently building 3,000 new homes each year. Our customers are vulnerable to energy hardship. Māori and Pacific peoples are overly represented in our homes.

The internal environment monitoring programme was set up to provide insights into how our homes are performing for our customers. The programme aims provide information to decision makers to support continual improvement and work towards improving energy wellbeing for our customers.

We are currently monitoring temperature and relative humidity in 180 homes. The sample includes new homes built to 6 Homestar v 4.1 and higher and older stock that has recently been upgraded to meet the Government's Healthy Homes Standards.

This work will present temperature and relative humidity metrics for the 2023 winter. This analysis is currently underway and will be complete in time to present in November 2023. Results are reported against building variables to provide insight into the drivers of low temperatures in our homes. We expect that newer homes are healthier in general but that many of them are still very cold.

It is concluded that the 6 Homestar v 4.1 homes we have been building since 2019 enable customers to live in healthier conditions. However, more work is needed to reduce the energy hardship for our customers living in older homes.

A sociotechnical Post-Occupancy Evaluation to uncover elements of practice for reducing fuel poverty and performance gaps

Authors: Luis Medrano[1,2], Paola Boarin[1,2], Alessandro Premier[1,2]

[1]University of Auckland

[2]Future Cities Research Hub

The interaction between occupants and buildings is a complex matter, particularly with the introduction of materials and technologies to enhance the buildings' thermal and energy performance. Evidence has shown that buildings are often uncomfortable and difficult to operate, and building professionals lack the precedent and tools to develop optimal buildings considering the complex nature of occupants. Sociotechnical approaches to comfort and energy consumption in buildings focusing on occupant behaviours have attracted increasing research attention. However, conventional behavioural decision-making studies lack enough depth and breadth as behaviours are just the tip of the iceberg. This problem is particularly important for residential retrofit as the predicted performance of buildings post-retrofit is often unmet, and occupant behaviours have been identified as a major cause for this gap.

A more recent approach to address this gap has incorporated Social Practice Theory, considering individuals as carriers of practices that are shaped by their know-how, engagement, explicit rules, and materials and technologies. This type of study has demonstrated promising results and can equip building professionals to face the current social and environmental challenges like fuel poverty and climate resilience by facilitating transformation in practices.

This Doctoral research presents a sociotechnical Post-Occupancy Evaluation (POE) that was developed incorporating Social Practice Theory and Participatory Design principles. Such POE is being tested in collaboration with the Otago Home Upgrade programme to expand our understanding of household practices related to retrofit measures and to co-develop intervention strategies based on people's needs and expectations. Preliminary results and emerging trends are presented.

Interim Report and Observations: the Otago Home Upgrade Programme

Authors: Scott Willis[1], Keita McComb[1], Zach Marshall[1], Jade Saville[1], Janet Stephenson[2]

[1]Aukaha (1997) Ltd

[2]Centre for Sustainability, University of Otago

The Otago Home Upgrade Programme is a $2.5M pilot programme funded through the Covid-19 Response and Recovery Fund shovel ready project initiative and managed by EECA. Beginning in March 2022, the Aukaha team has intervened in over 200 whare throughout Otago and have a target to reach 252 whare by the end of May 2024.

We ask the question, how can the Government support delivery-end partners to build a healthy ecosystem of energy wellbeing services and ensure energy wellbeing for all?

Aukaha is a manawhenua-owned consultancy that delivers services across the takiwā of our Papatipu Rūnaka shareholders. We are a partner with several government agencies, not just another stakeholder or client, and we have been monitoring progress through this pilot while we are engaged in delivering it. We have prepared this interim evaluation report, with support partners to guide improvements in delivery of home upgrade programmes nationally. We also seek to inform those directed by other agencies to deliver health and wellbeing and build resilience as climate impacts become more pronounced.

In this presentation we give a brief overview of the process and our proposed improvements to it. We use several case-studies to illustrate the impact of this pilot programme for whānau and provide recommendations to improve delivery.

We look further at the complexity of challenges, particularly relating to delivery of energy wellbeing to the 'hard-to-reach' whānau, dig into the challenges and their potential solutions and propose a pathway forward to ensure efficient delivery of energy wellbeing for all.

Habitat's Impact on Household Energy Savings

Authors: Courtanay Gray[1]

[1]Habitat for Humanity Northern Region

Habitat for Humanity is currently undertaking a pilot project with Ecology Associates to estimate household CO2-e emissions reductions and cost savings for the 1,387 households supported by our Healthy Homes Programme (HHP) in the past year.

Habitat's vision is of a world where everyone has a decent place to live, and HHP is a whānau-centric service that works with low-income households across Auckland and Northland to improve their homes' health, warmth, dryness and energy efficiency. Whilst we measure HHP's social impacts, it is important to understand the impact our energy efficiency advice and interventions have on cost savings and emissions reductions in the homes we serve.

This project applies a methodology used as part of Auckland Council's Live Lightly programme. Data from over 2,200 households engaged in that programme since 2017, based on household occupancy, has provided a baseline to assess the heating, lighting and hot water use emissions and costs of our HHP services. Habitat's interventions are assigned with efficiency coefficient factors which are then applied to estimate associated cost and emissions savings. These include reducing draughts, improving window coverings, reducing mould, insulating hot water cylinders, reducing shower flow rates, and replacing less efficient light bulbs with LEDs. In-home education is also provided on other behaviours to improve energy-use efficiency.

The presentation will outline Habitat's Healthy Homes Programme, its approach to energy wellbeing, and the methodology and findings of this exciting pilot evaluation – a first stage in our process to continually improve programme impact and reporting in this area.

Living labs for decarbonizing our campus

Authors: Arjan Abeynaike[1]

[1]University of Otago, Department of Physics

The University of Otago has run Energy Living Labs for several years, where students tackle real world energy problems with support from academics and university staff. This year two students looked at energy use in campus buildings with an aim to improve efficiency and reduce carbon emissions.

The first project looked at eliminating the biggest point source of carbon emissions in our Dunedin campus, an LPG-fired boiler for a modern research building. Our student identified options for electrification of this energy load and determined appropriate sizing for the equipment. The proposed system would halve energy consumption, reduce carbon emissions by 76% and save $150k per annum in fuel costs. A more detailed proposal is now being prepared by energy consultants with financial support from EECA. The second project studied energy usage and potential for solar energy in 100+ student flats owned by the university. Using half-hourly smart meter data, the daily energy use profiles were plotted, showing that students' energy consumption peaked in the mid to late morning, when solar irradiance is increasing. Student flats are therefore well suited to solar power and could utilise half of the solar power generated from their rooftops without the need for a battery.

These living labs have provided the students with excellent experience working on real world problems and developing useful skills, while also providing tangible benefits for the university.

How correcting misperceptions could help accelerate energy transitions

Authors: Dr Madeline Judge[1], Linda Steg[2]

[1]University of Otago

[2]University of Groningen

Energy transitions are collective action problems that require actors across different sectors of society to make coordinated changes to their current practices and behaviours. In collective action problems, an actor's willingness to take action often depends on their perceptions of whether others similarly intend to take action. However, evidence suggests that these perceptions can often be inaccurate, which could be inhibiting the rate of social change. In this talk, I will present some evidence of misperceptions in the context of the Dutch energy transition. Specifically, in an cross-sectional, nationally-representative survey of 951 Dutch citizens, we measured perceptions of whether various actors (e.g., family and friends, the current and future Dutch population, politicians, the fossil fuel industry, renewable energy companies, banks, environmentalists) think it is important to stop the production and use of fossil fuels. Participants tended to underestimate how many of their current fellow citizens thought it was important to stop the production and use of fossil fuels, though they expected this proportion to increase in the next five years. Perceptions that one's close social circle and other Dutch citizens were taking action against fossil fuels were the strongest predictors of one's personal social change actions. However, participants tended to assign greater responsibility to take action to politicians and industry than the general population, and also saw these actors as more efficacious. I will conclude by discussing potential sources of misperceptions, as well as a research agenda for potential strategies that could help correct misperceptions.

Physically-motivated approach to incorporating solar gain into a data-driven model of building energy consumption

Authors: Anthony Mirfin[1], Xun Xiao[2], Michael Jack[1]

[1]Department of Physics, University of Otago

[2]Department of Mathematics and Statistics, University of Otago

Predictions of building energy consumption are important for the measurement and verification of building performance improvements, energy management and savings, fault detection, optimisation of smart buildings, and estimating load on electrical networks. Popular approaches for predicting building energy consumption are data-driven models based on historical consumption data and weather data, most commonly outdoor temperature. Solar gain is also known to be an important factor that influences the heating and cooling demand of a building, yet previous attempts at accounting for solar fail to capture the complex physical dependency, leaving room for accuracy improvements. We incorporate solar gain in a modification of the well-established Time-of-Week and Temperature (TOWT) model. The modification considers important building physics constraints on solar gain, including orientation and the opposite impact of solar gain on heating and cooling. We apply the model to a case study based on a building simulation, with results showing a clear improvement in model performance across a range of different climatic conditions.

Expanded Porphyrin-like designer catalysts for electrocatalytic H2 evolution and selective CO2 reduction

Authors: Kieran DeMonte[1,2], Michael Bennington[1], Aaron Marshall[2,3] and Sally Brooker[1,2]

[1]University of Otago, Chemistry Department [2]MacDiarmid Institute for Advanced Materials and Nanotechnology
[3]University of Canterbury, Chemical and Process Engineering Department

The global use of fossil fuels results in unsustainable levels of CO_2 gas being released into the atmosphere, furthering the impacts of global warming.[1] Possible capture of CO_2 from high emission processes and subsequent selective reduction (CO_2 reduction reaction, CO_2RR) to convert it into renewable fuels could move those processes towards carbon neutrality.

To move towards carbon zero, green hydrogen is a desirable alternative to fossil fuels. Hydrogen has a higher energy density and only produces water as a waste product. 'Green' hydrogen is produced from water using renewable energy (hydrogen evolution reaction, HER). Most hydrogen produced currently, for use in industry, is 'brown' hydrogen made from fossil fuels in energy intensive and carbon emitting processes, so this must also be replaced by green hydrogen.

Catalysts are needed to reduce the energy of chemical processes, such as HER and CO_2RR,[2] to make them more energy and cost efficient. The CO_2RR is an energy intensive process with many possible products, highlighting the need for catalysts that can not only reduce the energy required for reduction but also produce the desired useful products selectively.

We have prepared a range of porphyrin-like dimetallic macrocyclic complexes,[3,4] and these are now being tested for electrocatalytic activity for HER and CO_2RR. This testing is being carried out under both homogenous and heterogenous conditions, the latter through immobilisation of the catalysts on solid supports. This presentation will cover the synthetic steps involved in producing these macrocyclic complexes and the results of the electrochemical HER and CO_2RR testing on selected complexes.

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Critical Minerals, Renewable Energy and Net Zero Carbon. Some New Zealand perceptions

Authors: Smrithi Talwar[1], Phil Glassey[1], Rachel Lawson[1], Xuemei Tang[1]

[1]GNS Science

Minerals are increasingly being used for low-emission, energy technologies such as solar, wind and batteries, fundamental for enabling a low-carbon emission global economy. Demand for these technologies will increase significantly in the next twenty years. Yet, there is little understanding of how the New Zealand public views mining, and the impacts of increased mining of these minerals to achieve the country's net zero carbon agenda. To improve understanding, we conducted an online survey of public perceptions and held a focus group discussion with University students in Wellington. Our focus was on how the public views trade-offs between biodiversity/ environmental protection and the need to enable a just transition to a net zero carbon emissions economy and society. We identified four broad themes from the responses:

- Balancing trade-offs in the transition to a net zero carbon economy where, on discussion, participants changed their positions regarding environmental protection versus mining for these minerals.
- Sustainability and circular economy discourses where reuse, recycling and reduced consumption were to the fore.
- Social responsibility, particularly towards indigenous communities and the need to address socio-cultural impacts in minerals extraction decision-making, and in particularly consider obligations under the Treaty of Waitangi.
- Actions the government should be taking, with the majority in favour of the Net Zero Carbon agenda but wanting increased transparency and communication of the New Zealand government's role in global stewardship, and in international standards, to address public concerns of the potentially unethical nature of some global supply chains.

Distributed energy resources: Fractal Grids

Prof. Malcolm McCulloch[1]

[1]Department of Engineering Science, University of Oxford

Day 2 Keynote

The nature of the grid is changing rapidly. The dominant concept of the grid simply moving energy in space is no longer valid. Due to the significant distributed storage resources, for instance in electric vehicles and heat pumps, implies that the emerging concept of a grid is that energy is moved through both space and time.

This transition requires new ways of thinking and new commercial models. A powerful model is that the same functionality of the new power systems is evident at multiple scales, hence the term fractal grid. Examples from both high-income countries and low income countries will be shared.

Bio: In 1993 Malcolm moved to Oxford University to start up the Electrical Power Group. Climate change, resource depletion and social inequity are the big challenges facing our civilisation. The group's focus is to develop, and commercialise, sustainable energy technologies. Malcolm has two active themes of research: energy access for the developing world and integrating renewable generation into existing grids. Malcolm's approach is to deeply understand the transition of the underlying system. Specifically, he focuses on the end users current and future needs and capabilities and to develop an energy system that grows with the end-user. He is developing a suite of techniques to accelerate system change. Specific projects include the exploiting the spatio-temporal nature grid, the weak hybrid grid, the provision of mobility and energy services from electric vehicles, and the use of effective thermal energy stores. Malcolm has spun out four for profit companies and two not for profit enterprises. He has over 250 publications and over 30 patent and patent applications. Malcolm believes that developing the technology is only the start. There needs to be a public awareness of the seriousness of the problems. Therefore, he has been instrumental, together with a small team of people, in conceiving and developing Tipping Point, an annual event to bring some of the top artists and climate scientists together. Through the creative use of the open space format, this forum has proved to be extremely successful that has found international acceptance. This has led to Malcolm being an advisor to Ian McEwan for his book Solar

Offshore wind electricity generation

Prof. Elizabeth J. Wilson[1]

[1]Arts & Sciences Faculty, Darmouth College

Day 2 Keynote

Bio: Dr. Elizabeth J. Wilson is a Professor of Environmental Studies and was the founding Director of the Arthur L. Irving Institute for Energy and Society (2017-2022). She studies how energy systems are evolving in the face of new technologies, new societal pressures and new risks. Her work focuses on how energy and environmental policies and laws are implemented in practice. Her current research focuses on Offshore Wind Energy and examines the gaps between policy goals and practice in different locations around the globe. She studies how institutions are supporting and thwarting energy system transitions and her work focuses on the interplays between technology innovation, policy creation, and institutional decision making. Past projects have examined how energy policy stakeholders engage with the opportunities and challenges of within Regional Transmission Organizations, which manage the transmission planning, electricity markets and grid operations for over 70 percent of North American electricity sales. Her research has also studied how stakeholders in different U.S. states view emerging energy technologies like wind power, carbon-capture and sequestration, the smart grids, and the electric power transmission system. Recent books include Energy Law and Policy, Third Edition (West Academic Publishing) (with Davies, Klass, Tomain and Osofsky) and Smart Grid (R)evolution: Electric Power Struggles (Cambridge Press) (with Stephens and Peterson). Wilson is on sabbatical until 2023.

Balancing multiple priorities in the Energy Transition - the Taranaki story

Authors: Jonathan Young[1]

[1]Ara Ake, NZ

The energy transition is slowly making its way out of policy rooms into industries workshops, but it needs to be at a pace which acknowledges both the urgency of change and the challenges of change. There are multiple priorities to balance in order to achieve a successful and sustainable transition. One great challenge is to advance innovation which will enable a reduction in emissions. Typical market incentives based on short to medium term economics may be too slow. The policy development of energy transition has been led by the Government, who have included social outcomes as a high priority. Beyond scientific practicality and economic feasibility, social priorities labelled as "A Just Transition" have added a further layer in the journey of change. This session identifies these layers in the energy transition and asks the question on their efficacy in achieving both climate goals and enduring social benefit for our communities.

Southland's energy pathway

Authors: Steve Canny[1]

[1]Great South, NZ

Supporting the energy transitions for Murihiku Southland

Authors: Mike Shatford[1]

[1]Murihiku Regenration NZ

Murihiku Regeneration is an Iwi led regional development construct led by the Murihiku-Southland Upoko through Hokonui Rūnanga by the Hokonui Health and Social Services Trust to support its members, Murihiku Hapū, the community, Iwi-Māori, and Ngāi Tahu whānui.

Infrastructure and energy are of critical importance for Murihiku Southland because they are essential for the region's economic growth and development; helping to connect people with opportunities, promoting economic growth and improve livelihoods. It should be acknowledged that significant progress has already been made around decarbonisation of the Southland economy, this can now be accelerated through forward planning and action. As such, the region is already progressing on its energy transition and faces uncertainty and a lack of forward planning, which will impact on the trajectory of growth.

Action in the Murihiku Region

As a high net GNP contributor relative to GDP, the success of Southland's energy transition and its potential positive impact on the productive economy for New Zealand, makes it a key priority for the region.

Through the Murihiku-Southland Regional Energy Strategy and the Murihiku Regeneration Energy Transition Plan will aim to activate enablers, then establish networks and then grow supply and demand.

Key Focus

The key areas of focus have been identified as:

- Getting certainty around the future of the Tiwai Smelter and the potential for the staged introduction of new high value industries by 2030.
- Enabling necessary policy and regulation, including a fast-track consents process for high value infrastructure projects to bring on new energy supply to match demand.
- Supporting innovation and the introduction of hydrogen and other low emissions projects that speed up the move to a low emissions economy. This includes a renewable energy hub and hydrogen refuelling network.
- Enable Rakiura-Stewart Island to have a low emissions pathway to net zero by 2030.
- Support targeted community and distributed energy projects.
- Focus a workforce plan to support future development.

From fossil fuels to local renewables: A research framework to address NZ's energy GHGs

Authors: Simon Arnold[1]

[1]CE, National Energy Research Institute (NERI)

Earlier this year NERI published this framework setting out the medium-term applied energy research themes NZ needs to be investing in if it is reach its goal of net zero GHG emissions by 2050 (www.neri.org.nz/GHGs).

The six themes are to:

- Develop the supply of clean fuels (electricity and biofuels) to meet the anticipated increases in demand;
- Clarify the fuel options for long-haul land transport and support their implementation;
- Reduce the demand for long-haul transport (land, air and marine);
- Develop clean/low energy industries;
- Address the major NZ-wide impacts from these changes; and
- Empower te ao Māori to contribute to these challenges and opportunities.

In this talk I will briefly expand on the themes and the processes used in their development.

Investment Feasibility in a 100% Renewable, Energy-only Electricity Market

Authors: Greg Sise[1,2]

[1]Energy Link

[2]Honorary Research Fellow, CEFG University of Otago

New Zealand has an energy-only electricity market in which expectations of future energy spot prices are a key driver of investment decisions by developers of new generation projects. As we move closer to 100% renewable electricity supply, spot prices are expected to become more volatile, creating greater uncertainty for developers. But not only do prices become more volatile, they also become more sensitive to the demand-supply balance, adding to this uncertainty. In this paper we explore the impact of this uncertainty, the relationship to the frequency of periods of scarcity (forced outages), and point to how and where enhancements need to be made to the market.

Decarbonising primary industries with geothermal – a pathway to greater direct use

Authors: Celia Wells[1], Phil Glassey[1], Anya Seward[1]

[1]GNS Science

Energy use in agriculture and food relies heavily on fossil fuels, with relatively limited penetration of renewables in these sectors to date. Despite significant potential to decarbonise parts of the primary sector with geothermal direct-use in New Zealand, there has been limited investment. Higher temperatures (>150°C) can be harnessed for industrial process heat or provide baseload energy in combination with other technologies to reach temperature peaks, among other forms of value addition. However, the most significant opportunities lie with low temperature geothermal energy (<150°C) that is available in many New Zealand regions. These temperatures can be harnessed to heat greenhouses, support industrial drying, dehydration, or cool storage.

Uptake remains low due in part to a lack of awareness, but more so because of the risks associated with investing in geothermal direct-use. With industry facing multiple pressures to decarbonise, more are assessing geothermal opportunities and asking how risk can be mitigated to reap geothermal energy rewards and are looking to successful case studies in Europe, especially horticulture in the Netherlands.

Obstacles to geothermal direct use are not insurmountable, this presentation will provide economic, policy and planning recommendations that address risk and allow for best practise environmental management. It will also draw on preliminary work by GNS Science, Ministry for Primary Industries, EECA's RETA programme, and horticulture industry collaboration to address barriers to uptake and unlock the opportunity. Additionally, we will highlight international evidence showing trends that primary industry investment leads to increased geothermal direct use in other industries and district-scale home heating.

Agrivoltaics: Appropriate typologies for farming operations in Aotearoa New Zealand

Authors: Juan Cabrera[1], Alan Brent[1]

[1]Sustainable Energy Systems, Wellington Faculty of Engineering, Te Herenga Waka Victoria University of Wellington

With the increasing concerns of global warming, energy production has a key role to play in reducing emissions and meeting climate change targets. Utility-scale photovoltaic (PV) systems are an important aspect of this response. However, a large drawback of these systems is their ground-mounted nature and requirement for large amounts of land to meet the threshold of economic viability, which calls into question a concern of converting potentially productive land for single-usage. As such, agrivoltaics (APV), or a synergistic combining of energy production via photovoltaic systems with ongoing agricultural practices on the same land are of growing importance globally. Precedents have been set in the USA, Japan, Germany, France, and Spain, where these systems have been defined and applied as documented in the Fraunhofer Institutes 'DIN SPEC 91434:2021-05' and Solar Power Europe's 'Agrisolar - Best Practices Guideline'. The potential of APV has been highlighted for Aotearoa New Zealand, but a typology of appropriate APV systems for various farming operations in the country has not been defined. This paper aims to do so and thereby pave the way to develop guidelines for optimized APV systems for the unique agriculture sector context. This paper defines the most current models and practices of APV, with an economic analysis of which farming systems may be best suited for the different typologies. Furthermore, a more in-depth case study of viniculture in different regions across the country reveals the potential economic benefits of APV uptake.

Industrial demand response to firm up a 100% renewable electricity system

Authors: Dr Jen Purdie[1], May Robertson[2], Assoc Prof Michael Jack[2]

[1]Centre for Sustainability, University of Otago

[1]Department of Physics, University of Otago

Firming up intermittency in a 100% renewable system will require significant investment in either:

a) pumped storage,

b) overbuild,

c) firm dispatchable power,

d) battery storage, or

e) demand response.

The incoming government has indicated it will not build the proposed Lake Onslow pumped storage scheme. It is therefore likely that firming, particularly in a dry year, will come from some mix of solutions b) to e). All of these solutions have significant costs and limitations, with demand response potentially offering the cheapest and most flexible solution. Residential demand response involves the short duration turning off of household appliances such as hot water heaters when intermittent renewable energy is not available (sun goes down, wind stops blowing). Industrial demand response can potentially provide significantly more demand response from a single electricity consumer, and for longer durations. We use an industry developed complex model of the New Zealand electricity system, LPCon, to model what demand response four large industries would be willing to provide, and the impacts of this on firming a renewable system on a fine temporal scale out to 2050. The four industries are Tiwai Point aluminium smelter (staying open to 2050), NZ Steel, Southern Green Hydrogen and three data centres. Industries were found to have to reduce load for a maximum of 3.5 months in the driest hydro lake inflows from a 90 year history. This resulted in a reduction of nationwide peak electricity demand required during this time of 12%, and many system efficiency gains.

Gravitational Energy Storage Systems to Optimise the Efficiency of Hydropower Generation Capacity in Aotearoa New Zealand

Authors: Andy Dynan[1], Alan Brent[1]

[1]Sustainable Energy Systems, Wellington Faculty of Engineering, Te Herenga Waka Victoria University of Wellington

Challenges associated with the transition to 100% Renewable Energy (RE) are not only limited to the changes in the physical assets, or the challenges to maintaining steady voltages and frequencies. Endemic processes and legislative requirements can add costly bureaucratic time restrictions to infrastructure projects needed to reach our (Aotearoa New Zealand) climate obligations. Understanding the intended trajectories toward 100% renewable energy and the how we reach these goals, whilst addressing the decline in grid inertia as we progress, can offer insight to where we should concentrate time and capital optimising existing infrastructure and developing new RE generation assets. A potential answer to the inherent issues in RE development is Gravitational Energy Storage (GES). GES is an increasingly popular solution to address power quality concerns and provides a platform to store energy profitably through arbitrage and can be deployed in a range of varying topologies. Accordingly, this paper outlines how the optimisation of Round-Trip Efficiencies (RTE) in GES systems can provide the pathway toward utilising these systems to optimise the efficiency of hydropower generation in Aotearoa New Zealand through a novel design that can be applied to our existing generation assets.

Load Forecasting for Dynamic Operating Envelopes

Authors: Sam Caldwell[1]

[1]Vector

Electrification of public transport (PT) is an important step in the transition to low-carbon energy systems globally. Electricity distribution businesses must reliably enable high-capacity charging infrastructure on the network at locations like bus and ferry stations for PT providers. To minimise cost impacts for these customers, connections should maximise the use of available capacity with their existing assets.

Distributed Energy Resources Management Systems (DERMS) via the delivery of Dynamic Operating Envelopes (DOEs) are being developed to manage this infrastructure development. In this instance, the electricity distributor provides the PT provider with a DOE to set the upper threshold for their charging loads throughout the day.

These DOEs rely on accurate load forecasts for other customers connected on the same part of the network hierarchy as the PT charging stations. These forecasts need to be responsive to network changes, growth, weather, and customer behaviours, whilst also being stable enough to ignore day-to-day load variability.

As part of this new technology, we are developing algorithms to provide these forecasts for several High Voltage Feeders and Zone Substations around the Auckland network.

This talk will involve exploration of relevant datasets and the evaluation of a range of machine learning and statistical time series methods to provide these forecasts.

Electricity Demand and Offset Emissions from Nationwide Heavy Battery-Electric vs. Fuel Cell Truck Decarbonisation in New Zealand in 2050

Authors: Wilson McNeil[1,2,3], Rebecca Peer[1], Jannik Haas[1]

[1]Department of Civil and Natural Resources Engineering, University of Canterbury

[2]Department of Civil and Environmental Engineering, University of California, Berkeley

[3]Energy Technologies Area, Lawrence Berkeley National Laboratory

Despite a relatively low share of total vehicle kilometres travelled in New Zealand, heavy freight has a disproportionate amount of carbon dioxide emissions, making it a target for decarbonisation. The New Zealand government has goals of reducing freight transportation emissions by 35% by 2035 and reaching net-zero by 2050. Two different technologies have the potential to electrify heavy freight: battery-electric trucks and fuel cell trucks. However, it remains unclear which truck technology will be used to reach this goal and how the electricity sector will need to evolve to meet increased demand from heavy truck electrification. An integrated assessment framework was developed to compare the energy requirement of heavy truck decarbonisation through battery-electric trucks vs. fuel cell trucks in New Zealand in 2035 and 2050. This framework includes freight demand, vehicle powertrain, truck operation and charging, and diesel emission models. Results showed that a full fleet of battery-electric trucks in 2050 would consume 7.17% of New Zealand's 2021 electricity generation compared to 10.2% for fuel cell trucks. A sensitivity analysis showed that for both battery-electric and fuel cell trucks, improved truck design and efficiency can reduce this electricity requirement. By 2050, electrification could reduce on-road emissions by over 2,422,000 tonnes of CO_2 eq., 930 tonnes of $PM_{2.5}$, 13,000 tonnes of NO_x, 2,400 tonnes of VOC, and 8,600 tonnes of CO.

New methods of low voltage outage detection for facilitating the energy transition

Authors: Evelyn Hunsberger[1]

[1]Vector

With increasing electrification and dependency on the grid, one challenge facing electricity distribution companies like Vector is to have full visibility of their outages, especially at the low voltage level. Whilst there are automatic methods for detecting high voltage outages, low voltage outages are currently reported via customer calls. To increase visibility of these low voltage outages, Vector is trialling novel methods that combine two existing technologies that communicate with household meters and modems. One technology enables signals to be sent to electricity meters, and the response indicates whether the premise has electricity. The other technology automatically sends a signal if the building's modem switches on or off. This granular level of data can be used to scan the network to discover outages, determine the extent of known outages and confirm electricity restorations. The results of these trials are combined with Vector's existing outage data to determine the accuracy of the granular technologies and develop a strategy to maximise coverage. As electricity customers become increasingly dependent on reliable electricity supply due to the energy transition, improvements in low voltage outage detection will be crucial to maintaining satisfaction and trust in the industry.

Metal fuels for zero-carbon heat and power

Authors: David Frost[1]

[1]McGill University

To address climate change, we must transition to a low-carbon economy. Many clean primary energy sources, such as solar panels and wind turbines, are being deployed and promise an abundant supply of clean electricity in the near future. The key question becomes how to store, transport and trade this clean energy in a manner that is as convenient as fossil fuels. The Alternative Fuels Laboratory (AFL) at McGill University (alternativefuelslaboratory.ca) is actively researching the use of recyclable metal fuels as a key enabling technology for a low-carbon society. Metal fuels, reduced using clean primary energy, have the highest energy density of any chemical fuel and are stable solids, simplifying trade and transport. The chemical energy stored in the metal fuels can be converted to useful thermal or motive power through two main routes: the Dry Cycle, where metal powders are burned with air, or the Wet Cycle, where metal powders are reacted with water to produce hydrogen and heat as an intermediate step before using the hydrogen as a fuel for various power systems. This talk will overview the concept of metal fuels and the various power system options that can contribute to the energy transition.