16th Otago Energy Research Centre Symposium 2022

Abstracts Booklet

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

SAPERE AUDE

OTAGO ENERGY RESEARCH CENTRE

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Fuel Poverty: A policy perspective from England

Dr Pam Wynne, Head of the Fuel Poverty Unit UK, BEIS

Bio: Dr Pam Wynne has been involved in the field of fuel poverty for a number of years. Leading the Fuel Poverty Team in the Department for Business, Energy and Industrial Strategy, Pam and colleagues work closely with a wide range of stakeholders across all sectors on the development and delivery of fuel poverty policies in England. This includes working with colleagues in other Government Departments and the Devolved Administrations of Wales, Scotland and Northern Ireland. The team also provides Secretariat for the Committee on Fuel Poverty – an advisory Non Departmental Public Body – who 'advise on the effectiveness of policies aimed at reducing fuel poverty, and encourage greater co-ordination across the organisations working to reduce fuel poverty'.

Pam has worked in a number of Government Departments through her career covering a wide range of policies including the social issues around development in London Docklands, local environmental quality and sponsorship of the construction materials industry. She is also co-Chair of the Carers Network in BEIS and is a Mental Health First Aider.

Day 1 Inaugural Keynote

Research on energy hardship using the energy cultures framework

Authors: Janet Stephenson[1]

[1]Centre for Sustainability, University of Otago

Abstract: A number of researchers in New Zealand and internationally have used the energy cultures framework to study energy hardship. The framework offers a holistic integrative structure around which to design research and analyse research findings, as well as to develop recommendations for interventions. I will discuss examples of energy hardship research undertaken in Ireland, New Zealand and Chile as well as an investigation of slum rehabilitation housing in Mumbai, Abuja and Rio de Janiero. These illustrate the various ways the energy cultures framework has been used methodologically and the kinds of insights that this approach can offer for policy.

Energy cultures framework and the Otago Home Upgrade Programme

Authors: Scott Willis[1], Keita McComb[1], Zach Marshall[1], Janet Stephenson[2], Ben Anderson[3]

[1]Aukaha Ltd

[2]CSAFE–University of Otago

[3]University of Southampton

Abstract: An elderly couple with health issues were confined to their kitchen without fixed heating because of problems such as a leaking bathroom, window rot and black mould in their home. These went unaddressed until they were referred into the Otago Home Upgrade Programme.

The Otago Home Upgrade Programme is a pilot programme resourced by EECA to trial a new approach in delivering energy wellbeing. So far we've visited over 50 homes in Otago and a raft of interventions are in motion. We're finding people in stressful situations through poverty and isolation or simply at a loss when faced with a critical repair / essential maintenance. Each case is unique and presents both opportunities and challenges.

One of our challenges is evaluating how effective our home interventions are. We're using the energy cultures framework to structure our evaluation process as we go, assess the impact of our interventions, and understand both the value for money in delivery and overall return on investment from a holistic perspective. We want to be able to inform future energy wellbeing work nationally. As we had expected, action research is messy but exciting.

Our presentation details our approach. We will present preliminary data and use case studies to illustrate the range of issues we're uncovering. This is work in progress, a snapshot, as we work with whānau to improve their material situation, change behaviours for the better and shift norms, to achieve energy wellbeing.

System Dynamics Model of Energise Ōtaki Solar PV Projects

Authors: Ryan Roberts[1]
[1]Victoria University of Wellington

1. Background

Local and community actors are beginning to engage in the Aotearoa energy sector. A few community renewable energy (CRE) projects have been established, however a majority struggle to get off the ground within the current energy generation landscape [1]. Moreover, very little data on the impacts of these projects exists. Different project designs and implementations can lead to different impacts [2] and it is critical for policy makers to understand these factors when shaping national/regional energy systems. New modelling techniques that can (a) capture the range impacts leading from emerging, local energy projects and (b) help identify intervention points within the system are key to providing suitable interventions. Systems dynamics is a tool that can meet these requirements and has been used in green economy modelling at national, regional and community level initiatives [3–6]. These models – with high interconnectedness between systems and feedback functions - are often used to run 'what if' scenarios, with the structure of the model developing theories about the behaviour of the system [7].

2. Objective

This research created a System Dynamics model based on the Energise Ōtaki solar generation projects (see Figure 1 below). It provides a framework for project operations and simulates the expected project impacts, through the use of the Whakahiko Ōtaki–Energise Ōtaki Fund. Furthermore, the model identifies leverage points that can affect key impacts from the project, such as project costs, GHG emissions avoided and community involvement.

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The importance of diversity of thought, experiences and co-design in the energy wellbeing sector

Authors: Bettina Reid[1]

[1]Te Puni Kōkiri Tai Tokerau Housing Advisor

Abstract: The importance of diversity of thought, experiences and co-design in the energy wellbeing sector and Te Puni Kōkiri Tai Tokerau holistic approach to housing repairs.

- Partnerships and tangata tiriti
- Intergenerational thinking mindset of Māori
- Removing barriers and understanding mistrust of crown or foreign organisations
- Opportunity of co-design – bringing diversity tickbox into driving equitable outcomes for all in respect to energy.
- Tai Tokerau Housing repair programme

Energy wellbeing in social housing – what is Kāinga Ora doing?

Authors: Tom Kane[1]

[1]Kāinga Ora

Abstract: Kāinga Ora houses over 180,000 people in nearly 70,000 homes and is currently building around 3,000 new homes each year. Many of our customers are vulnerable to energy hardship. The Kāinga Ora – Homes and Communities Act set a mandate for Kāinga Ora to enable our customers to live well in their homes. In practice, this means that we use our build and maintenance standards to achieve wellbeing outcomes for our customers.

Kāinga Ora have several initiatives designed to improve our homes and customer energy wellbeing. These include:

- The Healthy Homes Programme - upgrading our housing stock to comply with the Government's Healthy Homes Standards
- The Renewals Programme - deep retrofit on our oldest homes to bring them up to 6 HomeStar version 4 standard
- Innovative build programme - testing new construction materials, systems and build practices including building to certified passive house standard
- Renewable Energy Trials – providing solar PV to 1000 households.

We are currently developing a new approach to evaluating our initiatives from a customer health and energy wellbeing perspective. This approach will use health and wellbeing outcomes in the Integrated Data Infrastructure to compare the outcomes resulting from the different initiatives.

This will be supplemented by post occupancy data collected by our Internal Environment Monitoring programme. We are currently monitoring temperature, relative humidity and CO2 levels in around 150 homes. Early results show that homes built to our current minimum build standard, 6 HomeStar V 4.1, have fewer hours below WHO recommended indoor temperatures of 18°C than our older housing stock.

We hope to demonstrate that customers living in our homes built or refurbished to high building performance standards have low energy bills and healthy internal conditions.

Household-level Energy Hardship Rating

Authors: Philip Squire[1]

[1]Toast Electric/Sustainability Trust

Abstract: Energy hardship (EH) or fuel poverty is a term used to describe the inability of households to afford the required energy to maintain a healthy and dignified lifestyle. EH is typically described as being composed of a range of indicators including: Poverty; High cost of energy; and Poor house/appliance quality. The ability and knowledge of how to operate a home and reduce overall energy costs is also a contributing factor.

There are multiple definitions of EH/fuel poverty around the world and in Europe especially. As an example, the English definition broadly states that a household is in fuel poverty if they are living in an inefficient house (as measured by a quantitative home assessment) and if they spent the money required to heat the home to a healthy level, they would be below the official poverty line.

An EH Rating (EHR) at a household level could be used to assist in benchmarking and tracking changes in energy hardship for an individual household. An EHR that measures household levels of structural quality, heating/appliance efficiency, energy affordability and other contributing factors would be valuable in assessing the effectiveness of interventions, and monitoring a households overall level of EH over time.

ST sees a range of uses for a household-level EHR including targeting resources, responding to funders and stakeholders desire to see positive outcomes on a household level, and determining correlations between EH and a range of structural and demographic indicators. We also see value in the measure being used as setting eligibility for EH programmes and determining an end point for assistance.

Energy hardship severity: applying 17 of the proposed MBIE indicators

Authors: Luiza Brabo-Catala[1], Anca Cernic[2], Eva Collins[1], and Barry Barton[3]

[1]Management School, University of Waikato

[2]Vector Limited

[3]Faculty of Law, University of Waikato

Abstract: In Aotearoa, energy hardship means being unable to obtain and afford adequate energy services, which is mainly a result of low incomes, poor housing quality, and high energy costs. Inconsistency in defining and measuring energy hardship can lead to insufficient minimisation actions. Our goal was to find key indicators that can optimise identifying vulnerable households and planning specific actions. For that, two surveys were conducted: one with 773 respondents who are OurPower customers in Waikato, and a nationally representative survey of 505 respondents. Seventeen out of the twenty-six indicators proposed by MBIE, primarily connected to their material conditions and thermal perception, were used to identify the severity of energy hardship in the respondents' households. The three indicators which relate most strongly to the severity of the condition are connected to the dwelling's thermal perception. The single leading cause of energy hardship is financial adversity, connecting the condition to tenancy status, food insecurity, and health problems. Respondents of the OurPower survey presented more energy hardship indicators than respondents of the nationally representative survey.

Identifying energy hardship at a utility scale

Authors: Daniel Gnoth[1]

[1]Powerco

Abstract: Identifying energy hardship at a utility scale Energy utilities are regulated to maintain levels of security of supply whilst maintaining a balanced and uniform cost to serve. However, there are no direct measures to evaluate the impact of pricing or investment decisions on those experiencing energy hardship, nor any uniform ways of identifying hardship. An ad-hoc case study was undertaken on an electricity distribution companies' geographic footprint to overlay a variety of demographic measures for vulnerable customers. The study observed that areas of higher deprivation were often in older, more congested areas of the network which could impact service quality. This suggests further investigation and collaboration around network investment prioritisation processes and the role they play in mitigating energy hardship.

Understanding the performance of ultra-efficient housing in Dunedin

Maria Callau[1], Michael Jack[2]

[1]SUR Architecture

[2]Physics department, University of Otago

Abstract: International findings suggest that large-scale uptake of houses built to state-of-the-art ultra-efficient standards could provide significant health, financial, and climate benefits. Given New Zealand's poor housing stock and the consequences of this for energy poverty, health and the cost of decarbonizing the energy system, adopting ultra-high efficiency standards could be particularly beneficial. However, due to the small number (<50) of these buildings currently in New Zealand, there remains uncertainty about their performance in comparison to other building types. In this talk we will present results from an indoor air quality and energy-use study of a medium density cluster of 20 ultra-efficient houses in the cold climate zone of Dunedin. Results on indoor CO2, humidity, temperature, and energy use over a > 1 year period will be presented together with the results of a survey of occupant energy use behaviour and perspectives. These results will add to the evidence base for future building regulations in New Zealand and, in particular, directly inform MBIE's building for climate change programme.

Indicators of Energy Hardship: An Update on the Warmer Kiwi Homes Study

Authors: Caroline Fyfe[1]

[1]Motu

Abstract: Indicators of Energy Hardship: AN update This presentation provides an update on the work of the Energy Hardship Indicators Working Group. The purpose of the working group is to develop a set of indicators to measure Energy Hardship in New Zealand. These indicators are separate from and have a different focus to those used by MBIE in their definition of Energy Wellbeing. The indicators cover both causes (contributing factors) and consequences (outcomes) of energy hardship and fit into one or more of four categories:

- People and households
- Energy
- Wellbeing
- Home or Kainga.

A particularly distinctive feature of the indicators is that they are presented at a macro and micro level. The macro indicators measure the degree of energy hardship in New Zealand. The micro indicators identify households experiencing, or at risk of experiencing, energy hardship. Next steps are to:

- Formalise the indicator framework
- Add causal factor statements to each of the categories listed above, to sit alongside (aspirational) outcome statements.
- Identify both cause and outcome indicators at macro and micro level for each component.
- Identify data sources and data gaps

Hearing the voices of those living in "hidden" energy hardship

Authors: Dr Sea Rotmann[1]

[1]Sustainable Energy Advice Ltd

Abstract: After almost five years researching so-called "hard-to-reach" (HTR) energy users, we have come to the dismaying conclusion that this group includes the majority of energy users (Rotmann et al, 2020). There are many valid critiques of both the HTR terminology and current approaches used to try and engage these audiences, with the main one being that this language puts the onus on the energy user, rather than those "Behaviour Changers", as we call them, who are tasked with engaging them.

Another issue is that most Behaviour Changers assume low income to be the main identifier for HTR energy users. Our research has shown that is not necessarily the case. Energy users with increasing and intersecting vulnerabilities (such as minority status, renters, or geographic remoteness) are both, harder-to-reach and suffer increasing hardship. Unfortunately, many of these energy users remain hidden to Behaviour Changers in government, research and industry, either on purpose or because they are underserved, overlooked or stigmatised by society.

We are undertaking two field research projects that focus on those energy users living in "hidden" hardship. One (funded by MBIE's SEEC fund) has taken Home Energy Assessment Toolkits (HEAT kits) and tailored them to those HTR energy users. The second (funded by Mercury & Genesis Energy) engages frontline and community providers to delve deeper into the characteristics of marginalised energy users living in hidden hardship, with the goal of co-designing better interventions based on their, and their clients' needs. We will present preliminary findings from both.

Towards energy equity in mid-Canterbury–place-based collaboration

Authors: Sheralee MacDonald[1], Ivan Luketina[1], Casey Caress[1], Ed Leeson[2]

[1]Orion NZ Ltd

[2]Ōtautahi Community Housing Trust

Abstract: The energy transition brings a risk of an increasing inequity between those who can afford new and efficient housing, transport and other energy services, and those who can't.

Orion, as the mid-Canterbury electricity distribution business, is focused on powering a cleaner, brighter future for our communities, including how we can support energy equity and lowest whole of system costs.

Research has shown that place-based energy transition approaches could generate greater benefits and lower costs than place-agnostic approaches. A recent workshop brought together 16 entities to explore collaboration towards an equitable energy future for mid-Canterbury, which has resulted in a better understanding of the existing local initiatives, identified gaps and five initial opportunities to work together.

This presentation will provide an overview of current initiatives in the region addressing energy hardship (e.g. Community Energy Action, EcoBulb, Empower Energy), and collaborative projects to improve energy equity and wellness now and in the future (e.g. Climate Action Campus, Kia Kotahi Ako), with a focus on the Ōtautahi Community Housing Trust project with up to 17 households that Orion is supporting.

Reducing energy hardship: Making the case for new gentailers

Authors: Chris Lambourne[1]

[1]Manaaki Energy Inc

Abstract: Existing government, NGO and commercial responses do reduce the incidence of energy hardship amongst New Zealand homes, but despite these efforts energy hardship still significantly affects hundreds of thousands of people with an estimated 1,600 people per annum dying early deaths. Currently government spends approximately $600m per annum trying to reduce energy hardship. New solutions are needed.

The just transition to a low emissions economy remains beyond our grasp if we do not address today's inequities.

Manaaki Energy advocates for the creation of a new gentailer by the government that focuses on eliminating energy hardship. This new gentailer would:

- Social goals would drive the operation
- Service homes of people in energy hardship
- Run monitoring and analysis to ensure social objectives are achieved
- Own extensive solar, wind and geothermal generation plant
- Sell surplus renewable electricity to subsidise its social objectives
- Operate with a co-governance model with Maori
- Require at least a $1B of investment

Home repair programme in Te Tai Tokerau; Tamaki and Aotea Island

Authors: Leana Hunt[1], Carina Dickson[1]

[1]Habitat for Humanity

Abstract:

- Critical home repair / deep retrofit programme: successes and challenges.
- The importance of delivering in partnership, allowing whanau to stay on whenua, and advocate for systemic change to inequity.
- Social Return on Investment

Evaluation of the Maori and Public Housing Renewable Energy Fund

Authors: Jessica Kereama[1]

[1]Allen & Clarke

Abstract: In August 2020, the New Zealand government agreed to a $28 million fund for renewable energy installations. This Renewable Energy Fund is administered by the Ministry of Business Innovation and Employment (MBIE). The aim is to reduce household energy costs through renewable energy.

The Fund will trial and evaluate the impact of renewable energy solutions in public housing (through Kāinga Ora) and a selection of Māori housing through various Māori community organisations and housing providers. The goals of the Fund are to:

Contribute to affordable energy and improved wellbeing support decarbonisation empower tangata whenua/Māori to harness clean energy in line with kaitiakitanga and rangatiratanga and tikanga Māori. Specific objectives for households that receive the renewable energy solutions are to provide a reliable and secure energy source, reduce energy costs and improve health and wellbeing outcomes.

MBIE will use the pilot phase of the project to learn about the effectiveness of the different types of renewable energy solutions. This will explore the costs, benefits, and design options for distributed energy solutions at the household level, and which solutions would be suitable for a larger scale roll out.

Evaluation purpose and key questions

MBIE contracted Allen & Clarke to independently evaluate the effectiveness of the Fund and to assess the feasibility of continuing the interventions.

The purpose of the evaluation is to measure the impact of the renewable energy fund on the public and Māori housing streams. The evaluation explores the following key evaluation questions:

1. How much of the household energy requirements are met by the renewable energy interventions?

2. To what extent has there been an improvement in health and wellbeing outcomes for targeted households?

3. What is the comparative efficacy of the range of distributed energy solutions?

4. What has been the impact on equity?

5. To what extent does the implementation of the renewable energy systems offer value for money?

6. How well did the different aspects of the engagement and implementation processes work?

7. What have been the impacts for targeted Māori household? Co-design of the Māori housing stream evaluation

As well as the above questions, the evaluation team will work with recipients of the Māori Home Renewable Energy Fund in five selected rohe to co-design specific questions of interest to providers in the rohe.

Evaluation methodology

For the Māori housing stream, the evaluation will focus on five rohe (Wellington, Central North Island, Northland, Taranaki, Marlborough).

We'll work with Māori organisations who are funding recipients to identify households that have received renewable energy solutions, to invite these whānau to participate in the evaluation. We will gather data on energy use, monitor indoor temperature, and conduct a survey on household experience of the renewable energy for 100 households across the five rohe.

We'll also undertake kanohi-ki-te-kanohi interviews with a smaller sample of Māori providers who are funding recipients, households and whānau who have received the renewable energy solutions. These interviews will collect data about the process of applying for funding, receiving the renewable energy solutions, and any changes or impacts on wellbeing.

High-temperature heat pumps for process heat decarbonisation: A systems integration perspective

Dr Tim Walmsley, Assistant Director of Ahuora - Centre for Smart Energy Systems, School of Engineering, The University of Waikato, New Zealand

Bio: Dr Walmsley is an Assistant Director of Ahuora - Centre for Smart Energy Systems and leads the team's research on minimising process energy demand and the integration of high-temperature heat pumps. He is currently supervising 6 PhD students with topics in digitalisation, process integration and optimisation, and heat pump technology. His research is supported by Project Ahuora (www.ahuora.co.nz), an Advanced Energy Technology Platform, funded by the New Zealand Ministry of Business, Innovation and Employment.

Day 2 Inaugural Keynote

Currently, New Zealand burns over 110 PJ of fossil fuels each year to generate the process heat needed by our chemical and process industries. On the demand side, about half of this heat requirement is used in applications with temperatures between ambient to 200°C. In this temperature range, heat pumps have emerged as a critical piece of the industrial process heat decarbonisation puzzle. As a result, there is an ongoing push in Europe, North America, and Asia to develop a wider range of heat pump technologies that expand both the operating temperature window and seek to achieve multi-mega-watt scales. Based on research by the Ahuora team that looked at 200+ different refrigerant options and identified 50+ heat pump cycles, this keynote talk explores how heat pump performance is viewed from a systems integration perspective. It will discuss the inherent trade-offs that exist in the development of new heat pump technology, define when heat pump technology is more appropriate than biomass boilers for process heat, and conclude with the challenges and opportunities that lay ahead for heat pumps to operationalise decarbonisation in New Zealand.

German-New Zealand Green Hydrogen Centre: research, networking and outreach

Authors: Sally Brooker[1,2]

[1]Department of Chemistry, University of Otago

[2]MacDiarmid Institute

Abstract: Recently four German-NZ green hydrogen grants, funded on both the German (BMBF) and NZ (MBIE Catalyst) sides, have been awarded.

The first of these is to establish a German-NZ Green Hydrogen Centre for research, networking and outreach (2021-2026). Then three German-NZ Green Hydrogen research grants (2022-2025) were awarded:

1. "Safe, low cost, hydrogen storage materials from NZ resources", hosted at Otago University, but with an NZ wide team (me, A/Profs Michael Jack, Nigel Lucas and Dr Anna Garden (Otago); A/Prof Alex Yip (Canty), Dr Chris Bumby (Vic), Prof Peng Cao (Akl) and A/Prof Jonathan Lever (Unitec) in partnership with Aimee Kaio (Ngāi Tahu/Murihiku Regeneration) and Dr Linda Wright (NZ Hydrogen Council)), plus our partners at the Institute for Hydrogen Technology, Helmholtz Zentrum Hereon (led by Dr Paul Jerabek)

2. "Investigating ways of producing low-cost green hydrogen" hosted at Canterbury University (led by Prof Aaron Marshall)

3. "Creation of a New Zealand-German platform for green hydrogen integration" hosted at Canterbury (led by Drs Jannik Haas and Rebecca Peer).

This presentation will provide an introduction to, and update on, the above developments.

Southern Green Hydrogen and dry-year power system flexibility: The needs of the Aotearoa power system, a notional contract structure for supply, and trying to keep everyone happy

Authors: Grant Telfar[1]

[1]Meridian Energy

Abstract: A joint venture between Contact Energy and Meridian Energy is exploring the potential for a large-scale green hydrogen facility in Southland. As well as being an exciting global decarbonization project, this presents a unique opportunity to provide flexibility (sustained down) back to the power system when needed. Over time, intermittency management (both up and down), and other grid services could also be considered. As conventional thermal generation is retired from the power system over the coming decades and replaced by variable renewable energy, flexibility of all types will become increasingly important.

We outline here a structure for large-scale demand response intended to be commercially palatable, simple, and defendable both publicly and to multiple regulators who are increasingly focusing on 'efficient and fair' outcomes.

Exploring Expectations for Green Hydrogen in New Zealand using an Energy Cultures Framework

Authors: Abbi Virens[1], Smrithi Talwar[2]

[1]University of Otago

[2]GNS

Abstract: As a renewable energy vector, green hydrogen offers potential solutions for energy transition pathways in New Zealand. Being in the innovation stage, much of discussion and research surrounding this emerging technology focuses on the expectations for its future implementation. Thus, current research exploring the social dimension of green hydrogen is limited to expert knowledge of this technology describing its likely applications and barriers within the context of New Zealand. Using interview data from green hydrogen experts and preliminary case study data, this talk explores the potential elements related to green hydrogen application in New Zealand through an energy cultures analysis. These preliminary expectations help to create a picture of what this technological adoption could look like, what materials it could require, what kind of energy-use practices it would involve and ultimately how it could (or could not) fit into New Zealand's energy transition pathway.

Hybrid Renewable Energy Generators for Remote NZ

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

[1]Powerhouse Wind Limited

Abstract: Many parts of NZ are still characterised by a sparse or tenuous electrical infrastructure. Climate change will exacerbate this weakness.

Historically, providing electrical services to remote customers involved either the use of subsidised lines and/or diesel fuelled generators. New technologies are creating opportunities to tackle the rural energy trilemma by meeting domestic, community and commercial needs with distributed renewable generation. On-site renewable generation reduces the weather risk to long strings of lines and mitigates diesel usage in times of crisis.

Photovoltaics (PV) and lithium-ion batteries provide the backbone for off-grid services, but a significant problem is still the variability of PV production, both seasonally and on the local weather scale. Oversizing the panels and the batteries is a simple but expensive answer to energy security. Instead, one can diversify generation by supplementing PV with a high-performance wind turbine. Wind is far less seasonally characterised than solar, and there is a correlation between overcast conditions and wind. Wind can help fill the solar gaps minimizing diesel usage. Powerhouse Wind Ltd is researching the integration, and verifying the value proposition, of such a hybrid generator. The PowerCrate™ is a factory tested, relocatable, 20' container module, that is deployed or stowed on site within 2hrs. The modular format can aid rural energy equity as it reinforces prospects for the emergence of subscription style service in remote environments.

The presentation highlights the technical opportunity, the current realization of our system and its potential applications in different sectors of NZ society, geography, and economy.

Topographical surface tension gradients for effective water management in energy technology

Authors: Kirill Misiiuk[1], Richard Blaikie[1], Andrew Sommers[2], Geoff Willmott[3], Sam Lowrey [1]

[1] Department of Physics, University of Otago

[2] Department of Mechanical & Manufacturing Engineering, Miami University

[3] Department of Physics, University of Auckland

Abstract: Effective water management is required in numerous well-investigated industry applications and in developing green technologies: condensation control to prevent erosion of steam turbine blades[1], condensation control in Heating, Ventilation and Air Conditioning (HVAC)[2], and prevention of drop impact erosion and the icing on wind turbines[3]. Metals and their alloys are still a significant part of the energy sector, having the main issue of having strong adhesion during liquid-solid interactions. Coatings might not be applicable under certain limitations. A possible solution could come from nature: micro- and nano-structured surfaces like the pillar-wetting gradient of cicada wings[4]. Moreover, some spider silk demonstrates sub-millilitre droplet motion on a surface tension gradient created by knot-joint couplings[5]. Such a system does not require external forces, including gravity, for droplet transportation.

Aiming to find one solution for various scenarios of droplet behaviour (condensation and deposition/impact at different temperatures), we investigated all-metal passive gradient surfaces [6] produced via a one-step laser ablation process [7]. These surfaces demonstrated the spontaneous motion of certain-sized droplets, which is beneficial for providing drop-wise condensation over film-wise [6].

We will present the results of recently performed drop impact experiments, which show a strong correlation between the bouncing outcome and the gradient topographies. Moreover, the results of the ice removal test will be presented, demonstrating the direction dependency of the ice adhesion on such kind surfaces. The results may be beneficial for steam turbine blades, enhancing water droplet removal, and wind turbine blades, potentially delaying ice formation.

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Exploring the relationship between the economy, energy, and transition

Authors: Solis Norton[1]

[1]Mansford Station

Abstract: New Zealand's planning toward net zero emissions in 2050 is based on economic modelling. This modelling assumes a generally healthy economy.

Our global and national economies are at present in a state of rapid, volatile change. The overarching understanding is that a healthy economy grows at about two percent per annum, balancing inflation and unemployment.

The growth of an economy depends on the growth of its energy supply. In the last decade collective evidence strongly suggests global energy supply is shifting from growth into decline. This after exponential and generally steady growth over more than half a century.

This presentation will highlight the evidence for this phase shift and contrast it with what has been the economic status quo since the 1940s. It will explore the challenges and opportunities this presents the New Zealand economy and our ambitions of transition. It uses international examples drawn from the current energy crisis in the European Union.

Coating-free Surface-tension Gradient Networks for Enhanced Condensing Heat Exchanger Surfaces (Poster)

Authors: Chris Hughes[1], Sam Lowrey[1,2], Richard Blaikie[1,2] Andrew Sommers[3]

[1]Department of Physics, University of Otago
[2]MacDiarmid Institute
[3]Department of Mechanical and Manufacturing Engineering, Miami University

Abstract: Condensation and frosting are common phenomena across many heating, ventilation, and air conditioning (HVAC) systems. Surface coverage of condensation or frost presents a heat transfer resistance between the surface and surrounding environment, often an integral component of system's operation. A reduced need to defrost and/or remove condensation from heat transfer surfaces reduces energy expenditure and thus increases the efficiency of the system. As such, the development of heat transfer surfaces with anti-frosting qualities has become an area of interest [1] [2]. In the present work, aluminium surfaces with coating-free topographical networks of surface tension gradients, inspired by nature [3], are investigated for their microdroplet growth mechanisms and frost wavefront propagation velocity. Previous work found that in-plane forces acting on droplets with sub-capillary length diameters result in spontaneous droplet motion [4], or aid in surface defrosting [5]. It is thought that this will enhance surface water management by removing condensed droplets at smaller radii and hinder frost wavefront propagation across the surface, making the surfaces useful for heat exchanger applications. We present preliminary results from our experimental investigations into condensation and frosting on these surfaces. We first describe the construction of a subsonic wind tunnel to produce controlled condensation and condensation-frosting conditions, together with image processing methodology that allows the generation of growth curves that track average droplet radius and surface droplet concentration over time, similar to literature methods [6]. We will present preliminary results of growth curves and frost wavefront velocities on a variety of surfaces, including surface tension gradients.

References:

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Empower Energy Charitable Trust (Poster)

Authors: Brian Stephens[1], Michael Fitzgerald[1]

[1]Empower Energy

Abstract: Empower Energy is building a universal donation and distribution platform that will directly address energy hardship by sharing surplus energy and funds to reduce energy bills.

The concept was refined through the 2021 Orion Energy Accelerator program, where it was apparent that a third party, retailer agnostic entity was required to achieve donations from all New Zealanders who were wanting and able to contribute towards relieving Energy Hardship. The distribution side of the platform is a simple to use funding allocation tool that partnered Caring Agencies are free to use to help their clients.

To make a big impact in Winter 2023, while steadily building the platform donor base, Empower Energy are seeking 'Super Donors' to contribute cash donations directly to the hardship fund to reduce the bills for a meaningful number of families in hardship. Assuming a one-off hardship credit of $100 per family, Empower Energy aims to raise $1.5 million dollars of super donations to help 15,000 families in the first year, through a small number of partnered Care Agencies. Your feedback can help develop the Empower Energy model.

The platform requires development funding to be able to scale and automate, and build the donor communities and distribution networks, so platform partner funding is being sought from Energy Sector organisations, philanthropists, and Central Government.

A hierarchical control algorithm for flexible multi-energy-storage systems

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Abstract: The volatile and CO2 free energy infrastructure of the future needs energy efficiency and flexibility to become a reliable, secure, and economic energy system. A higher energy efficiency and flexibility can be realized by coupling the electricity and heat sector, which results in new multi-energy systems with intelligent controls. One of the controller methods are model-predictive controls (MPC) which include forecasting of energy production and consumption. The MPC has been proven successfully in the past in thermal application such as heating, ventilation, and air conditioning systems. In all MPC naturally there is a deviation between the forecasted values and the real values. These could lead, depending on the application of the MPC, to dramatic problems. The analysis of the resulting problems using real energy components and how to deal with them is the focus of this presentation.

The method used here is to extend the MPC control to an Hierarchical MPC (HMPC). Another level of control is added, which takes over the control between the optimization time steps. Through the new fast rule-based algorithm, corrections are made to the optimized prediction of the charging and discharging of the storage systems. The implementation of the optimized control on a laboratory testbench and the simulation of the new hierarchical control are carried out using a PV combined heat and power, battery, and thermal storage system in a household application. As a result, it is found that the hierarchical control is necessary to prevent the battery charging and discharging from and into the power grid when the PV and load forecast deviates from the real values. The control can also be applied to PV-heat-pumps system.

Determining the true value of energy efficiency improvements and demand flexibility services

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

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Abstract: Demand-side initiatives such as energy efficiency improvements and demand flexibility - where consumers shift their demand to reduce peaks - are vital for cost-effective decarbonisation. Pay-for-performance programmes pay participants based on actual energy savings and demand reduction and have the potential to bring demand-side initiatives onto a level playing field with the supply-side. However, accurately determining the true energy savings or demand reduction can be challenging. One approach that is currently receiving a lot of attention is to use a building's smart meter data from before the intervention to develop a baseline energy consumption model and compare this with the energy consumption after the intervention. In this project we aim to use the output from a building simulation to construct an improved baseline model. We will present preliminary results and discuss future directions.

Modelling the Long-term Impacts of EV Uptake within a 100% Renewable New Zealand Power System

Authors: Aleida Powell[1], Michael Jack[1], Jen Purdie[1]

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Abstract: Reducing CO2 emissions in New Zealand requires decarbonisation of the vehicle fleet. One way of achieving this is through rapid uptake of electric vehicles (EVs). The increased electricity demand of EV charging will impact the New Zealand electricity system, which is also transitioning to a 100% renewable system by 2030. This study analyses the potential long-term impacts of rapid uptake of EVs on the electricity system to 2050 using LPCOn - a detailed, least-cost optimization model of the New Zealand electricity system.

A series of scenarios were constructed to explore the potential impacts of varying degrees of EV uptake under four alternative charging behaviours ranging from daytime only to night-time only charging. Three uptake levels were analysed: (i) a medium level uptake of only light vehicles; (ii) the Climate Change Commission's (CCC) projected uptake of light EVs required to meet emission reduction targets, and (iii) the CCC's projected uptake of light and heavy EVs required to meet emission reduction targets.

Findings indicate that high EV uptake could lead to EV charging demand accounting for 17% of peak electricity demand by 2050 in the absence of controlled charging. Shifting EV demand to only occur at night reduces peak demand significantly, resulting in a more efficient and reliable system. However, night charging was found to lead to higher average prices of electricity and battery storage becoming less economically viable. These results highlight electricity grid and market wide impacts of EVs when considering both the decarbonisation of electricity and transport sectors.

Detection of electric vehicles at household level from half-hourly smart meter data

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Abstract: As part of the drive to efficiently build the electricity network of the future, Auckland electricity distribution business Vector has been undertaking a project to detect the presence or absence of specific large energy-using appliances at ICP level from half-hourly smart meter data. Electric vehicles (EVs) have been the primary focus of this project, due to their large energy consumption and rapid rate of uptake. This presentation outlines the progress so far in using machine learning to detect EVs from residential smart meter data. Methodologies and performance metrics will be briefly introduced before presenting accuracy results, as well as the proposed next steps for this project.

Will net-zero energy buildings break New Zealand's electricity grid?

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Abstract: Net-zero energy buildings produce enough renewable energy (usually via solar PV) to meet their own annual energy requirements and have been proposed as an important method of reducing operational greenhouse gas emissions in the building sector. However, self-generation via solar PV has the potential to increase seasonal variability in net electricity demand, causing challenges for future highly-renewable electricity supply systems. In this paper we explore scenarios of future large-scale uptake of solar-PV net-zero energy housing in New Zealand and quantify the seasonal variation of the resulting net electricity demand. The results show that solar PV self-generation with standard tilt angles can significantly increase seasonal variation but very high tilt angles (especially in southern regions) limit this variation and thus electricity grid impacts.