



# Otago Energy Research Centre

10<sup>th</sup> Symposium 2016

&

Transport Colloquium 2016



## Abstract Booklet



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**Gerry Carrington**

**Emeritus Professor, University of Otago**

From 1973 to 2008, Gerry was a member of staff in the Physics Department, University of Otago, where his research focused on technologies for improving consumer energy efficiency.

He has published 120 research papers, as author or co-author, and he wrote the textbook, "Basic Thermodynamics," published by Oxford University Press in 1993. At the University of Otago, he helped to establish courses in energy management, led the introduction of the interdisciplinary Applied Science programme, and helped to set up companies for improving energy efficiency in industry.



Gerry is an Emeritus Professor at the University of Otago, a Fellow of the Royal Society of New Zealand and a Fellow of the Institution of Professional Engineers of New Zealand. He is a trustee of the National Energy Research Institute and the Blueskin Resilient Communities Trust. In 2009, he was awarded the "Outstanding Contribution to Sustainable Energy Award" by the Energy Efficiency and Conservation Authority, and was noted by the judging panel as being "a leader of change based on academic principles" and "an educator of future generations of energy specialists."

Gerry is also the founder of the National Energy Research Institute (NERI), an independent, research evidence-based organisation that strives to be a 'thought-leader' of the energy sector.

**Andrew Jackson**

**Deputy Chief Executive, Ministry of Transport**

Andrew Jackson has been the Deputy Chief Executive of the Ministry of Transport since August 2011. He chairs the Ministry's high level policy group which decides the Ministry's overall portfolio of work considers aspects of transport policy and builds policy capability within the Ministry.

He was previously Deputy Secretary in the Ministry of Economic Development where he was responsible for policy relating to regulation of financial markets, company law, intellectual property and competition law and trade tariff policy. Prior to that he worked for the UK's Chief Scientific Adviser Sir David King on UK science policy and helped lead the UK's Foresight programme, which used science to help tackle challenging issues such as obesity, drug use and cybercrime.



### **Greg Sise**

#### **Managing Director, Energy Link Ltd**

Greg started in the energy industry in 1984, initially in energy management, but from 1992 widened his areas of activity to include the supply side of the electricity industry, undertaking a wide range of consulting and software assignments. He was on the Board of the Energy Efficiency and Conservation Authority (EECA) from 2007 to 2010, is currently a member of the Institute of Directors, and over the last 12 years has been a member of a number of industry working groups.



### **Chris Staynes**

#### **Councillor, Dunedin City Council**

Chris is a third term Councillor. A long term resident of Dunedin, Chris was General Manager of the Fisher & Paykel Range and Dishwasher plant in Mosgiel for 20 years. He retired in 2006 after serving 35 years with the company. Chris is currently a non-executive Director of Scott Technology Limited, Chair of the Cargill Enterprises board, a member of the Otago Polytechnic Council and is a member of the Institute of Directors in New Zealand (NZIM).

He has served as a Director and President of the Otago Southland Manufacturers Association, and is a Director of the Otago Chamber of Commerce. He is also a trustee of 4Trades Apprenticeship Training Trust and the OSMA Trust. Chris is the Councillor representative on the Otago Museum Trust Board. In 2006 Chris was named Business Personality of the year at the Westpac Otago Chamber of Commerce Business Excellence Awards.



### **Janet Stephenson**

#### **Director, Centre for Sustainability**

Janet Stephenson is passionate about collaborative, interdisciplinary research. Her research interests include indigenous resource management; the interconnections between people and their local environments; and the role of individuals and organisations in the transition to a sustainable future. Most of her current research applies social science approaches to energy and mobility transitions.

Janet has been Director of the Centre for Sustainability since February 2011. Her academic background is in sociology, planning and human geography. She first joined the Centre as a Senior Research Fellow at the end of 2008, having previously taught in the Geography Department at Otago University from 2001-2008.

She chairs the National Energy Research Institute, the Smart Grid Forum, and Dunedin City Council's Sustainability Audit Subcommittee.



## 1. GEOMAGNETICALLY INDUCED CURRENTS IN NEW ZEALAND ELECTRICAL NETWORK

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*Authors affiliations: [1] University of Otago, [2] Transpower New Zealand Limited, [3] Victoria University of Wellington New Zealand, [4] British Geological Survey, United Kingdom, [5] GNS Science, New Zealand, [6] British Antarctic Survey, United Kingdom.*

This joint NZ-UK project aims to investigate the risk posed by Geomagnetically Induced Currents (GIC) to NZ's electrical network. GIC in NZ's electrical network are caused by space weather storms. During these storms, the increase in fast moving charged particles in the upper atmosphere leads to induced electromagnetic fields at ground level resulting in damaging direct current flowing through earthed transformers. During very large space weather storms GIC can cause significant damage to electrical transformers. As an example in November 2001 a Dunedin transformer was written off after the impact of a large storm that caused multiple alarms across Transpower's South Island network.

In this talk we will present our early analysis of probably the best GIC dataset in the world; GIC measured continuously at multiple transformers for 17 years by Transpower, a key stakeholder in this project. We will also present our model to calculate GIC in NZ's network. Our goal for the model is to explore the impact of 100 year return period space weather storms and to evaluate mitigation protocols to reduce these impacts. New Zealand's geo-magnetic latitude and island setting mean that we are able to use modelling approaches which have been successfully applied in the past for the United Kingdom. As we will validate our model against the extensive Transpower observations, this will be a valuable confirmation of the modelling approaches used by the wider international community as well as contributing to the security of NZ's power supply.

## 2. QUANTIFYING THE BENEFITS FROM THE SPATIAL DIVERSIFICATION OF WIND POWER IN NEW ZEALAND

*Author: Dougal McQueen*

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Wind power is one of the least cost forms of electricity generation, which along with the need to reduce carbon emissions, means that wind power capacity will certainly increase. The turbulent nature of wind and the passive reaction of wind turbines ensures that wind power is variable. The variability in power increases the requirement for system reserves to ensure power quality is

maintained. Integration studies are undertaken to determine what impact wind power development will have on the power system and an often reached conclusion is that spatial diversification can alleviate some of the impacts. However, many of these studies fall short of quantifying the benefit of spatial diversification. To quantify that benefit requires models of wind power that are spatially and temporally consistent and congruent with other forms of generation and demand. A wind power model is formed, starting with wind speed time-series from the European Centre for Medium-range Weather Forecasting reanalysis which are interpolated, scaled and imputed. The imputation requires a model of turbulence and a Wavelet Multi-resolution Analysis model is developed that accounts for the heteroskedasticity of wind while enforcing the correct temporal and spatial correlations. The wind speed time-series are transformed to power using wind power plant power curves and a Low Pass Filter that accounts for the effect of spatial integration. To demonstrate the benefit of spatial diversification in the New Zealand power system four scenarios are developed representing 2 GW wind power portfolios. The scenarios are Compact, Disperse, Diverse, and Business As Usual (BAU). Metrics for reliability, variability, and predictability are defined that reflect the structure of the New Zealand Electricity Market. The conclusion is that a compact wind generation portfolio will exhibit lower reliability, a diverse portfolio will exhibit less variability, and a disperse portfolio will exhibit greater predictability. The BAU scenario shows that the existing portfolio of Wind Power Plants in New Zealand achieves some of the benefits of spatial diversification, however greater benefit could be achieved through careful planning.

### 3. HOUSEHOLD POWER PROFILES: INSIGHTS FROM DEMAND DATA

*Authors: Kiti Suomalainen<sup>a</sup>, Michael Jack<sup>b</sup>, David Evers<sup>c</sup>*

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*Authors: Salma Bakr, Stephen Cranefield*

The daily power demand profile of an individual household is determined by the sum of appliances using electricity at any given moment. Patterns arise with daily habits such as showering, turning on the heating after work and cooking dinner. These peaks in the demand profile can become significant for the electricity system operator if they coincide with peaks of the neighbouring households.

Typical evening peaks require extra power capacity to be switched on, often of the more expensive and carbon intensive kind, which could be avoided if the total demand profile was flatter. The two main strategies to flatten demand are changing users' behaviour and installing storage capacity. The challenge is to know how much of each is feasible for a given household. We need to know how common the undesired peaky profiles are and the main drivers for such profiles.

To study these questions, we have collected circuit-level data (e.g. hot water cylinder, heat pump or kitchen appliances) from 42 households at one-minute intervals, and data on household

characteristics, such as number of occupants and their ages. The minute-level data is crucial in order to identify the actual height of the peaks, something that the more commonly-collected half-hourly data tends to smooth out. This data set allows us to gain insights on the demand side dynamics of individual households, and investigate daily demand profiles—e.g by weekdays and weekends, household characteristics, and the role of certain power intensive technologies such as electric water heating systems or heat pumps.

## 4. ENERGY IN NEW ZEALAND'S FOOD SYSTEM

*Author:* Warren Fitzgerald

*Author affiliations:* Centre for Sustainability, University of Otago

New Zealand's primary food production chain earns around half of our export income and is extremely important to our national prosperity and identity. A strong international reputation surrounding New Zealand food production has been established over many years based on world class farming, processing, and distribution systems. However, these systems are tightly linked to the energy and climate issues which are a growing focus of political and consumer attention around the world.

Since ratifying the Paris agreement, and its subsequent entry into force, New Zealand is now bound to reducing its greenhouse gas emissions in an attempt to limit global temperature rises to well below 2°C. Emissions from ruminant animals consistently receive the most attention, but the entire food system, from paddock to plate, is maintained by intensive energy inputs, the majority of which originate from fossil fuels.

Recognising the essential role of energy in primary food production is therefore fundamentally important and will be a key part in successfully meeting the requirements of global agreements and changing market demands.

This presentation aims to visually represent the energy flows of our primary food production chain, and use this to stimulate conversation on the significant challenges and opportunities in this area.

## 5. EXERGY IN NEW ZEALAND

*Authors:* Caitlin Tromop van Dalen

*Authors affiliations:* Dr Michael Jack, Dr Muthasim Fahmy

The energy systems of most countries are monitored and studied using energy balances, which show the allocation of primary energy resources through transformation processes to end-uses. This can be a useful way of monitoring trends or changes in the way a country uses its energy resources, but does not account for the quality of these resources. Electricity and mechanical work are higher quality and more valuable energy carriers than low temperature heat. Exergy is



an alternative to energy for describing the value of a fuel or the output from an end use process. Unlike energy, exergy can be destroyed. It is this destruction that can offer additional insights into inefficiencies with resource utilisation.

This project includes an exergy analysis of the entire New Zealand energy system. It tracks mass flow of energy resources through New Zealand, considering chemical compositions of these resources and how they are transformed to consumer energy products. Transformation processes include electricity generation, cogeneration, and other transformations. Consumption processes include end uses in the agricultural, industrial, commercial and public services, residential, and transport sectors. Exergy efficiency and destruction are calculated for all of these resources use methods. Some key results include: a strong justification for a shift to electric vehicles; a clearer understanding of the utility from the geothermal sector; and supporting evidence of the value of heat pumps over other end-use heating technologies.

## 6. MEAT PROCESSING DAF SLUDGE TRANSFORMATION TO BIOFUELS VIA HYDROESTERIFICATION

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Hydroesterification is a biodiesel production process which significantly increases the number of possible feedstocks that can be utilised as lipid sources. This is because the transformation pathway facilitates biodiesel production by circumventing high free fatty acid and moisture content concerns of low grade lipid sources such as dissolved air flotation (DAF) sludge. The hydroesterification process integrates two stage transformations, involving hydrolysis of the lipids to fatty acids followed by a highly efficient esterification reaction for biodiesel production. In this paper, the hydrolysis of locally sourced DAF sludge was investigated under the action of a quasi-homogenous catalyst and the biodiesel properties of the esterification reaction product, which is composed of a mixture of methyl esters, were predicted. The chemical pseudo formula for the DAF sludge triglyceride, hydrolytic product and the methyl ester mixture were also developed. The possibility of utilising a preliminary hydrolytic reaction in the utilisation of DAF sludge as a biodiesel feedstock was therefore efficiently demonstrated. Crucially also the estimated fuel properties of the DAF sludge derived biodiesel satisfied the requirements for utilisation as vehicular fuel according to the European standards for biodiesel vehicular use (EN 14214).

Health, safety and cold flow properties of the DAF sludge and biodiesel product respectively were identified as major concerns which may inhibit future utilisation of this feedstock as a low grade lipid source. These concerns were extensively discussed and possible solutions were proposed.

## 7. PARENTAL PERCEPTIONS FAVOUR WALKING COMPARED TO CYCLING TO DUNEDIN SECONDARY SCHOOLS: PRELIMINARY FINDINGS FROM THE BEATS STUDY

*Authors: Sandra Mandic<sup>1</sup>, Debbie Hopkins<sup>2</sup>, Enrique García Bengoechea<sup>3</sup>, John Williams<sup>4</sup>, Charlotte Flaherty<sup>5</sup>, Antoni Moore<sup>6</sup>, John C. Spence<sup>7</sup>.*

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**Background:** Parental perceptions influence how adolescents travel to school. This cross-sectional study compared parental perceptions of adolescents' walking versus cycling to school.

**Methods:** Parents (n=113; age: 47.6±5.1 years; 79.6% females; living ≤4 km from their child's school) from Dunedin, completed an online survey on their children's (age: 13-18 years) transport to school habits and parental perceptions of walking and cycling to school.

**Results:** Overall, 50.4% of adolescents regularly walked, 32.7% were driven and only 5.5% cycled to school. Most parents believed that decisions about their child's walking or cycling to school should involve parents (34.0% parent-only and 29.1% parents-and-adolescent decisions) whereas 24.3% believed it was an adolescent-only decision. Compared to walking, parents perceived cycling to school as more unsafe (9.6% walking, 53.9% cycling) and less desirable (62.8% walking, 35.6% cycling), with less parental support (73.8% walking; 29.4% cycling), adolescent-peer support (38.8% walking, 9.9% cycling) and school support (37.6% walking, 14.9% cycling) and greater parental preference for their child not to cycle to school (15.0% walking; 57.8% cycling) (all p<0.001). Over half of parents perceived their child was capable to cycle to school (65.7%) and had very good/excellent cycling skills (58.6%) whereas 18.9% did not allow their child to leave home alone with a bicycle.

**Conclusions:** Parental preferences about adolescents' transport to school favoured walking compared to cycling to school. Combined with the perceived parental responsibility in decision making about walking or cycling to school, future interventions should address parental barriers for active transport, and especially cycling to school.

## 8. WHAT INFLUENCES INTENTION TO CYCLE TO SCHOOL? PRELIMINARY FINDINGS FROM A COMPARISON BETWEEN CHRISTCHURCH AND DUNEDIN

*Authors: John Williams<sup>1</sup>, Jillian Frater<sup>2</sup>, Sandra Mandic<sup>3</sup>*

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**Background:** Cycling to secondary school has health and energy co-benefits. This cross-sectional study examines how adolescents' perceptions and opinions are correlated with their intention to cycle to school, using data from the BEATS study for Dunedin, and a separate study in Christchurch.

**Methods:** Secondary school students (n=403 in Dunedin and 291 in Christchurch) who were living  $\leq 4$  km from school completed an online survey about their transport to school as well as their perceptions and opinions regarding cycling to school. Questionnaire construction was partially guided by the Theory of Planned Behaviour, which is a popular model of the proximate cognitive determinants of volitional behaviour. Using multiple group structural equation modelling (SEM) the latent variables Intention, Attitude, Subjective Norm and Perceived Behavioural Control were modelled with responses to the questionnaire.

**Results:** A multiple group SEM constraining the factor loadings (i.e. the measurement model) to be equal across cities, necessary for comparing regression paths in a meaningful way, yielded acceptable fit (CFI=0.978, NFI=0.966, RMSEA=0.073, SRMR=0.042). The table below shows the standardised path coefficients, which can be interpreted similarly to Pearson correlation coefficients.

City	Attitude	Control	Norms
Dunedin	0.42	0.14	0.16
Christchurch	0.35	ns	0.52

The effect of attitude on intention is similar between cities, but Norms and Control have radically different effects. In particular, in Christchurch control has no effect, and in Dunedin control and norms have similar effects to each other.

**Conclusions:** Where cycling is uncommon, positive attitudes are not sufficient: parental and peer support, and self-belief, are necessary for positive intentions.

## 9. INTERVENTIONS FOR A SUSTAINABLE TRANSPORT SYSTEM IN NEW ZEALAND: RESULTS FROM A DELPHI STUDY

*Authors: Sam Spector<sup>1</sup>, Janet Stephenson<sup>1</sup>, and Debbie Hopkins<sup>2</sup>*

*Authors affiliations: <sup>1</sup> Centre for Sustainability, University of Otago <sup>2</sup> Transport Studies Unit, University of Oxford*

This presentation will highlight results from the fourth and final round of a Delphi study with New Zealand transport experts. In the previous round of the Delphi the participants nominated the trends, innovations, and step changes that are needed to enable New Zealand to thrive economically, environmentally, and socially. In the final round the participants were asked to describe which interventions are necessary to achieve those priorities.

Key interventions related to changing how transport is funded; equalising mode-share when planning, building, and managing networks; better recognising the cost of climate change on the economy; changing urban form policies; and beginning a significant shift in Government policy. Other categories of interventions included improving rail, changing the consultation process, increasing the uptake of low-emission and electric vehicles, and improving education. The study demonstrated that significant changes are required if New Zealand is to attain a sustainable transport future. The experts' suggestions offer a road-map of the interventions that are required to work towards that future.

## 10. DESIGN THINKING OF SINGLE PASSENGER ELECTRIC VEHICLES FOR NEW ZEALAND URBAN USERS

*Authors: A/Prof Tom Qi and Dr. Zhengchun Fu*

*Authors affiliations: Otago Polytechnic*

Since electric vehicles are encouraged in New Zealand, discussions have been extended from marketing to technical supports e.g. building Electric Vehicles (EV) recharge stations network and training qualified EV maintaining technicians. However, though the EV becomes a popular passenger transport around the world, it is still not quite acceptable by New Zealanders. This presentation states a design thinking of single passenger EV for New Zealand urban transport network, i.e. considering value of balancing desirability, feasibility, and viability. The discussion on desirability is focusing on what the most New Zealanders want for the transports in urban area, where we enjoy living in independent houses while working and entertaining within a short distant e.g. offices, schools, shopping centres, hospitals, local parks and beaches; the feasibility is confirming our available technologies, which enable battery charging with standard power plugins in house without a need of standard carport; and the viability is to ensure we are able to

build our own EVs network in New Zealand. The conclusion of such a design thinking is that ultra-small size EVs are more better met the needs of New Zealand urban users e.g. such a ultra-small size EV has the best solution to car parking and battery recharging issues in New Zealand urban transport network. Most importantly, such a design allow the New Zealanders to step into the new world of Internet of Things e.g. such ultra-small size EVs are network connected to be ready for self-driving, though most of the time the owners of those vehicles are able to enjoy their driving with assisted by the connected network. These vehicles can be grouped and randomly appointed a driver of this group of vehicles without physical connections.

## **11.FLIP THE FLEET: A CITIZEN SCIENCE APPROACH TO ACCELERATING UPTAKE OF LOW EMISSION VEHICLES IN NEW ZEALAND**

*Authors: Henrik Moller<sup>1</sup>, Dima Ivanov<sup>2</sup>, Pam McKinlay<sup>1</sup>, and Alan Wilden<sup>1</sup>.*

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Encouraging uptake of Low Emission Vehicles (LEVs) in New Zealand requires extraordinary efforts to overcome barriers of misconceptions amongst potential purchasers, absence of strong financial subsidies and regulatory incentives to buy LEVs, and sparse rapid charging infrastructure. We have developed a citizen science approach to better inform public and businesses of LEV practicality, financial rewards, and their environmental and social benefits. LEV owners and fleet managers upload monthly dashboard metrics and data stored in their vehicles' computer to the Flip The Fleet database. Software instantly demonstrates and benchmarks each vehicle's performance, efficiency, cost savings and Return on Investment, battery degradation rate, electricity demand, and its environmental and social benefits. A full-scale marketing campaign, concentrating on social media, will spread the lessons emerging from the project into intimate places and times where mainstream media will not reach. This paper considers the main opportunities and barriers to successfully realising our aims to (i) empower LEV owners to better advocate for their neighbours, colleagues, fellow ratepayers and business shareholders to operate LEVs, (ii) build confidence amongst potential purchasers by sharing real data in local New Zealand conditions, (iii) provide a learning platform for LEV owners to optimise their charging patterns, financial benefits and battery care, and (iv) eventually provide a fine-grained and national database and sampling platform to support research on policy and business initiatives to accelerate LEV uptake throughout New Zealand.

## 12. DESTABILISATION AND DECLINE OF EXISTING REGIMES: THE ROLE OF ENTREPRENEURS IN THE NZ TRANSPORT INDUSTRY

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Moving to a low carbon economy in New Zealand requires, in part, a shift away from the current transport system (The Royal Society of New Zealand, 2014). Indeed, the current New Zealand transportation system would have a number of issues to overcome including old vehicle stock, old inefficient ICE engines, lack of rail infrastructure investment, low petrol taxes relative to OECD countries and a focus on road building (Vivid Economics & University of Auckland Business School, 2012). Globally too, it is suggested that climate change represents “formidable challenges” for transport (Geels, 2012: 471) as deep seated changes are needed to facilitate carbon reductions. Using a socio-technical systems approach to understand transport transitions is suggested to identify interactions and alignments between the many different factors of the system (Geels, 2012; Geels & Kemp, 2007). Even so, the complexity involved in destabilising current transportation regimes means a transition will be difficult. Starting a business that relies on destabilising such an embedded regime can thus be a hard journey. This paper looks at the entrepreneurs operating businesses that challenge the mainstream and dominant transportation regime in New Zealand. It explores each entrepreneurial venture to understand the business, the product/service offered and perceived barriers for scaling. However, with barriers come opportunities and these entrepreneurs are seeing and seizing opportunities that may have the potential to destabilise the current regime into one that is more sustainable.

## 13. THE ROLE OF QUALITATIVE AND FEASIBILITY STUDIES IN THE DESIGN AND ADMINISTRATION OF LARGE-SCALE QUANTITATIVE TRANSPORT SURVEYS

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**Background:** Transport choices affect teenagers’ ability to independently access key activities and destinations. Consequently, it makes sense to consider the role that transport plays in

influencing well-being. We report on field methods used prior to a large-scale online survey assessing this association.

**Methods:** Participatory photography (“photovoice”) uses photographs to provide a comprehensive description of an issue. This qualitative method was utilized among senior secondary school students aged 16-19 years in Southland, New Zealand (n=18), to evaluate their transport habits, and whether or not these habits influenced their well-being. 2 Following the photovoice project, an online pilot survey was developed and conducted with another sample of teenagers (n=55), measuring the same association, in order to test for feasibility.

**Results:** Photovoice findings suggested that transport issues played a key role in both supporting and obstructing well-being among participants, and these findings informed pilot survey content. Pilot survey findings confirmed a web-based survey was an effective and efficient way to survey older teenagers, and informed on content changes, delivery methods, and resource management for the final large-scale study.

**Conclusions and Recommendations:** Transport field research among older teenagers, such as photovoice studies and piloting surveys prior to larger and costly main studies, is an essential approach to uphold good science, avoid missed opportunities, and ensure the collection of quality data. This paper serves as a reminder of the value of respondent orientation as an overriding principle in research, which can be assured by conducting preliminary investigations, such as those detailed here.

#### 14.A CRACK IN THE AUTOMOBILITY REGIME? EXPLORING THE CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE URBAN MOBILITY POLICY IMPLEMENTATION IN THE CITY OF SÃO PAULO, BRAZIL.

*Authors: Tarcisio Barbosa Pinhate*

*Authors affiliations: University of Auckland*

Cities account for the majority of greenhouse gases emissions worldwide with a great part of that coming from the energy sector, and particularly from transportation. Nonetheless, cities are at the same time the place where responses to climate change are emerging from. Taking this into consideration, this thesis examines the opportunities and challenges for transitioning from an automobile-based urban mobility regime to a sustainable one in the city of São Paulo, Brazil. Drawing on the socio-technical transitions literature, this research makes use of the multi-level perspective (MLP), a framework understanding regime shifts to sustainability in three analytical levels, namely: the landscape, regime, and niche levels. Based on qualitative data, the research finds that the political will of the current local administration (2013-2016), as well as external factors such as the 2013 protests and activist movements provided a window of opportunity for the implementation of sustainable urban mobility policies in São Paulo. Those policies include

opening a public laboratory for innovation development in urban mobility, creating a participative transport council, reducing speed limits, and implementing infrastructure such as bus lanes, bus corridors and cycleways. However, this work also finds that despite the progress that has been made so far, automobility seems to remain the dominant urban mobility regime in São Paulo, reinforced by social practices and governance factors discussed in this research. Furthermore, recent changes in the political scenario with the election of a new municipal administration could potentially modify the window of opportunity for sustainable mobility policy in the city.

## **15.A SHORT HISTORY OF THE USE OF RENEWABLE ETHANOL AS A TRANSPORTATION FUEL.**

*Authors: William J. Wells*

*Authors affiliations: University of Otago, Dunedin*

Renewably-derived ethanol, synthesized primarily by fermentation of annual crops, is growing in use steadily worldwide in transportation applications owing to several important features of this ancient alcohol: (1) reductions in harmful tailpipe emissions relative to all-fossil petrol; (2) reductions in carbon dioxide emissions relative to all-fossil petrol owing to renewal of the crops by photosynthesis (it is a liquid solar fuel); (3) supply of cost-effective octane quality without resorting to toxic/carcinogenic alternatives such as aromatics, lead, or ethers; (4) improved productivity/lower medical costs in high-population urban airsheds where petrol pollution/smog causes health problems; (5) improved balance of trade/jobs, especially in agrarian nations without sufficient petroleum under their soil; (6) support for agricultural programs which are in need in many countries; and several other key points.

This paper will give a short history of how the fuel ethanol industry sputtered to life and finally caught hold in the last 30 years, primarily owing to replacement of toxic octane alternatives such as tetraethyl lead. An overview of recent worldwide use is given, with focus on Brazil and the USA as well as prospects for future advanced technologies beyond the traditional manufacture using common baker's yeast. Closer to home, use of ethanol in New Zealand petrol is discussed.



## 16. COMMUNITY ENERGY IN OUR CHANGING CLIMATE

*Authors: Scott Willis*

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In 2015 Blueskin Energy Ltd submitted a Resource Consent application for the first significant electricity generation proposal in Dunedin in over 100 years. The proposal for a community wind farm was also a New Zealand first. This presentation looks at what happened next (and what is happening now) and in particular explores a series of questions. For example, when community organisations are proponents of renewable generation projects, what particular challenges and opportunities do they face both before and within the RMA process? What is the role of the National Policy Statement on Renewable Electricity Generation in particular in its relationship with existing and forthcoming Plans? This presentation explores not only the legal and policy environment for community scale renewable electricity generation projects, but also the public environment, and considers how the RMA process might have to be adapted if we are to make the transition to a low carbon society before we are overtaken by climate crisis.

## 17. CLIMATE SAFE HOUSING

*Authors: Katharina Achterberg, Tobias Danielmeier, Chris Fersterer, Martin Kean, Scott Willis*

*Authors affiliations: Blueskin Resilient Communities Trust (KA & SW), Otago Polytechnic (TD, CF & MK).*

Climate change is affecting our environment, and is now lapping our doorsteps. Our built environment and housing in particular is now being affected by rising sea-levels and a corresponding increase in hazards. This is simply from an incremental increase in sea-levels at present. The Cosy Homes mission – to make every Dunedin home warm and cosy by 2025 – presents a significant challenge without any additional complexity. And yet, the climate is rapidly changing, and with it, so must our housing.

The Climate Safe House project emerged from a problem – a woman in fuel poverty in a mortgaged and previously flooded home with no heating, hot water or insurance – and a workshop – involving the Energy Efficiency and Conservation Authority, Otago Polytechnic, Cosy Homes and Dunedin City Council, organised by the Blueskin Resilient Communities Trust.

We are in the early days of this collaborative project looking at housing, energy and climate. Our presentation examines what meaningful collaboration will look like, and details the scale of the issue. For example, a recent paper by Hansen et al suggests that multi-metre sea-level rise from ice melt is exponential rather than linear and the authors' modelling indicates a strong potential for rapid sea-level rise over a metre by 2050. We are therefore faced not only with enormous

technical and economic challenges, but also a critical political challenge: creating local climate solutions together, to inspire national action.

## 18.ON GRID STORAGE

*Author: Hagen Bruggemann*

*Author affiliation: ev-lution*

I will present live data from my home system, which was the first in Australia and New Zealand. This is the equivalent to what the Tesla power wall represents, but it has already been in operation for two years. I will project the data live and also will present some real Solar-and domestic wind yield data collected on my property in Waitati.

## 19.HELPING SUPPORT ENERGY MANAGEMENT SYSTEMS AT THE UNIVERSITY OF OTAGO

*Authors: Paul Crane(a), Mark Mason(b), Hans Pietsch(b), David Evers(a).*

*Authors Affiliations: (a) Computer Science, University of Otago. (b) Property Services University of Otago.*

The University of Otago needs tools so as to be able to meet various goals, such as: accurate reporting (TEFMA, governmental, financial, non-financial); budgeting; and sustainability. Existing tools for energy management on campus are not suitable for the task as they are either no longer available, take ownership of the data, or don't interoperate with all the existing systems. In this talk, we discuss our initial experiences trying to integrate the various systems on-campus. By developing an integrated system, we aim to track energy from procurement, through conversion to different forms and its distribution. The system must meet the requirements of occupants, sustainability targets, and other obligations. In tracking the energy in this manner, we can optimise the energy used across the campus, facilitate various levels of reporting, and assist with ad-hoc metering requests.

## 20. MODELLING DOMESTIC ELECTRIC HOT WATER CYLINDERS FOR DEMAND MANAGEMENT

*Authors: Jefferson Dew and Michael W. Jack*

*Authors affiliations: Department of Physics, University of Otago, GREEN Grid*

Domestic electric water heaters account for a large proportion of electricity use particularly during the morning peak period in New Zealand. In order to reduce this contribution to peak demand, ripple control has been used for many years, however much more intelligent control systems are now becoming possible. To evaluate the demand management potential of hot water cylinders under modern control scenarios we simulated hot water cylinder electricity demand via a simple physical model of a hot water cylinder and assumed household usage patterns. The simulated electricity demand was validated using monitored electricity use data from a number of hot water cylinders.

With this approach the potential for hot water demand management to reduce peak electricity demand can be evaluated for different households and appliances. In addition to the changes in electricity demand, the effect of various control scenarios on hot water supply could be assessed. A number of control scenarios were investigated including a household load smoothing regime that reduced peaks by up to 40% and had a minimal effect on service.

## 21. TECHNICAL AND ECONOMICAL FEASIBILITY OF THERMOCHEMICAL HEAT ENERGY STORAGE SYSTEMS FOR RESIDENTIAL SPACE HEATING IN NEW ZEALAND

*Authors: Ruby-Jean Clark and Zhifa Sun\**

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Renewable energy resources are yet to be fully implemented as a result of the mismatch between generation and consumption. Solar energy can be stored via thermal energy storage and then released later for space heating requirements. We have analyzed various types of thermochemical energy storage reactors and materials available and developed a thermodynamic model based on an open system using the working pair of strontium bromide,  $\text{SrBr}_2 \cdot 6\text{H}_2\text{O} / \text{SrBr}_2 \cdot 1\text{H}_2\text{O}$ .

The model was used to discuss the feasibility of the system for residential space heating requirements in the two locations: Auckland and Dunedin. It was found that the system can work without humidification in Auckland, giving an output temperature of 30°C. The Dunedin system

can provide this output temperature, but humidification of the air is required. The systems gave a power output of 5.24 and 4.75 kW in Dunedin and Auckland respectively, at a specified dry-air flow rate of 0.825 kg/s, which is the average flow rate for a heat pump. In both regions, the summer (December-March) sunlight hours gave enough energy for the reaction to be sufficient for space heating requirements from April to November.

When the system was used as an alternative for mechanical heat pump energy consumption in the respective locations it was found the system is economically feasible in Auckland as the system will be approximately the same capital cost of a mechanical heat pump. This suggests further research should be conducted to make thermochemical energy storage systems a renewable energy source alternative for New Zealanders in the future.

## **22. POWER TO THE PEOPLE: 10 YEARS OF FUEL POVERTY RESEARCH IN NEW ZEALAND – WHERE TO FROM HERE?**

*Author: McKague, Fatima*

*Affiliations: Centre for Sustainability and Department of Marketing, University of Otago*

1 in 4 households in New Zealand are fuel poor, or unable to afford adequate warmth at home. For the past ten years, researchers in New Zealand have been trying to draw attention to the health and economic impacts of living in cold, damp houses. Yet, the challenges of fuel poverty and the solutions to it have not received sufficient policy attention in New Zealand. This paper explores the limitations and opportunities for fuel poverty policy in New Zealand. We look at the various policy options for alleviating fuel poverty and make recommendations by drawing on interviews conducted with key stakeholders and based on best practices from abroad. The findings highlight the imperative for immediate and sustained attention to undertake research-led policies and strategies to reduce fuel poverty, and to improve the quality of life of households in New Zealand.

## **23. GREG SISE KEYNOTE ABSTRACT: DOES THE ELECTRICITY MARKET FAIL AS RENEWABLES APPROACH 100%?**

The percentage of renewables in the national generation mix has recently exceeded 80% on an annual basis and appears to be on a rapid rise toward the government's target of 90% by 2025. New Zealand's deregulated energy-only electricity market was developed during an era when the fossil-fuelled thermal sector was more prominent than it is today. Retention of the energy-only market model for the long term, as the renewables penetration approaches 100%, assumes that it can meet demand in an economically efficient manner. But there are early warning signs

that this assumption may not be well founded. This presentation briefly outlines the issues and challenges, and gives some early results from modelling of the energy-only market as renewables approach 100%.

## 24. AN INTERNATIONAL COMPARISON OF THE EFFICIENCY OF ELECTRICITY FUTURES MARKETS

*Authors: Fergus Bevin-McCrimmon 1, Ivan Diaz-Rainey 1, Xing Han 1, Greg Sise 2.*

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Electricity represents one of the most volatile commodities in the world. Coupled with the presence of frequently occurring price spikes, this creates a need for financial products available to market participants to hedge this exposure. Futures contracts are one such instrument. Accordingly, the importance of futures markets has been noted by regulatory bodies across the world.

However, in order for futures contracts to achieve their desired objective, their underlying market should display signs of efficiency. Though the debate surrounding market efficiency has spread to a variety of commodity markets, it has yet to be applied to the same extent in the context of electricity markets. Furthermore, though there are futures markets operating across several liberalised electricity markets, some for over a decade, it appears that there has yet to be a comparison across these markets from a market efficiency perspective.

This papers address this gap in the literature by examining the validity of the unbiasedness hypothesis across five of the major electricity markets: Australia, Germany, New Zealand, Nord Pool and the PJM Interconnection. This grouping provides a cross section of generation mix, spot market design and market activity.

Surprisingly, the least mature and smallest market, New Zealand, exhibits the greatest degree of efficiency as per the unbiasedness hypothesis. However, as one would expect, all five markets appear to be showing signs of improving efficiency over time.

## 25. EMERGING ENERGY CONSUMERS

*Authors: Daniel Gnoth, Eric Pellicer*

*Authors affiliations: Powerco*

As the ability to create and store energy at a domestic level becomes more accessible, customers are becoming increasingly interested in alternative energy options. Distributed generation and storage can be an opportunity for lines companies who are required to optimise the use of their

assets by steadying demand profiles. Enabling energy sharing across the network could provide better value for energy producers as well as provide new opportunities for reducing network peaks.

However in order to understand how the market may respond to new technologies, distributors need to first learn who their customers are, and what their capacity is for the shifting of peak energy demand. Smart meter data from 11 thousand houses was analysed within the New Plymouth area over a two year period. Daily load profiles from each house were then clustered into five distinct groups depending on when energy was used.

The study found that a traditional ‘twin peak’ load curve was less prevalent in most houses, and that instead evening peaks were the most common load profile. This provides new insights into how distributors can enable households to shift their demand out of peak times and to move towards a model where customers are able utilise their neighbour’s solar energy.

## 26. ARE THERE GREATER GREENHOUSE GAS EMISSIONS DURING ELECTRICITY PEAKS?

*Authors: Imran Khan<sup>1</sup>, Michael Jack<sup>2</sup>, Janet Stephenson<sup>1</sup>*

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Many countries are focused on increasing the amount of renewable resources in their electricity supply. As electricity demand is variable in nature and renewables often cannot easily increased when needed, one concern is that high percentages of renewables will result in greater fossil fuel generation during times of peak demand, due to the use of gas or coal peaking plants. New Zealand already has a high percentage of renewable electricity, at more than 80% in 2015. It is therefore interesting to investigate whether or not greenhouse gas emissions associated with electricity generation during peak demand periods is greater than non-peak periods. In this study, using information from the Electricity Authority we calculate the average carbon intensity from electricity generation in gCO<sub>2</sub>-e/kWh for each hour of the day to determine the variability in this intensity and evaluate if it increases during peak times as expected. In addition, we also investigate the seasonal variation in carbon intensity of electricity generation. Our results show that the presence of a significant hydroelectricity component in New Zealand, which can effectively be utilized as energy storage, significantly complicates the picture of greenhouse gas emissions associated with peak demands.