

Geothermal energy

Geothermal energy is produced by extracting hot water and steam from deep underground reservoirs. It is an important energy source in New Zealand, producing approximately 14% of domestic electricity supply.

Internationally there is a growing interest in geothermal energy as the world searches for clean energy sources.



The geothermal modelling group at the University of Auckland conduct world-leading research which applies sophisticated computer models to discover how geothermal systems work. These models can be used to address questions such as:

- How long will the Wairakei geothermal power station keep working?
- How do geysers work?
- Will hot dry rock projects in Australia be successful?
- What is the future of geothermal energy?

The geothermal modelling group has developed computer models of many geothermal systems in New Zealand and overseas, including Wairakei, Ohaaki and Ngawha. Results from these models help understand the properties and structure of these reservoirs. This in turn helps geothermal reservoir engineers optimise future development plans for these resources. The group collaborates with counterparts at Lawrence Berkeley Laboratories in California to further develop the capabilities of the computer modelling codes they use. The modelling software used in the geothermal modelling group is being applied to model possible production of natural gas from hydrate deposits which lie off the New Zealand coastline.

Biodiesel options for New Zealand

It is widely accepted that New Zealand (and the world) will need to move to renewable transport fuels in the future. New Zealand has many resources for this option including tallow from meat processing and alcohols from plant and milk byproducts.

At the same time there is increasing concern about the possible harmful effects of engine exhaust emissions on human health and the environment. The question is: are emissions from engines fuelled with renewables less harmful than those fuelled conventionally?

The Energy and Fuels Research Unit has undertaken detailed measurements of particulate matter and polyaromatic hydrocarbon emissions. These have been done for engines operating on biogas and on gasoline/kerosene blends. The first of these is a valuable renewable fuel sourced from organic waste and the second is an adulterated fuel commonly used in some South Asian countries. Similar emissions from renewable fuels of relevance to New Zealand are being investigated. The fuels include biodiesel (sourced from vegetable or tallow) and alcohols potentially sourced from milk by-products or woody matter.

Biodiesel from tallow

Biodiesel is more expensive than petroleum derived diesel fuels. One of the causes of the cost difference is that conventionally, biodiesel is produced in a batch like process. The reaction time of this process can reach up to one hour, depending on the reaction conditions used. Costs are further increased by the need for high grade feed stock, which can also be very expensive.

The main objective of this project is to improve the economic viability of manufacturing biodiesel through a combined approach:

- use of a continuous reactor to improve the reaction rate
- using tallow, a waste by-product of the meat processing industry, as the fat feedstock for the process.

A new continuous reactor is being developed. Tallow is introduced into the reactor as a fine droplet spray and reacts with methanol at an optimum temperature. This reduced the reaction time from an hour to a few seconds.

This new continuous process is able to use any fat or oil as feedstock, including those containing impurities, making this form of biodiesel a cost-effective fuel which utilises an abundant waste product.



The University of Auckland Faculty of Engineering Energy Research Theme



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Introduction

Access to suitable energy supplies is a crucial component of the quality of life we enjoy. Energy is also an important issue for the economic competitiveness of businesses in New Zealand and abroad. As a society we must address how to meet our increasing energy demands in a sustainable way which balances economic and population growth with climate change.



Manapouri Power Station

Research questions around energy are wider than those that can be addressed by the Faculty of Engineering alone. Researchers in the Energy Theme maintain a variety of linkages across the University which enable them to work in a context which includes the broader scientific, business and social issues involved. Many energy researchers in the Faculty of Engineering are internationally acknowledged as experts in their respective areas and work on a range of projects in New Zealand and overseas.

The Energy Theme targets improved energy supply and use. This incorporates new sources of energy, sustainability of current forms of energy supply and novel low energy usage technologies.

Focus areas for the theme include:

- **Energy supply:** including coal-bed methane, gas hydrates, oil and gas production, geothermal energy, solar power, wind energy, carbon dioxide sequestration, electricity generation and infrastructure and markets
- **Energy use:** encompassing aluminium smelting, energy efficiency, transport fuels and biofuels, heat transfer, refrigeration and sustainability/complex systems.

University researchers within the Energy theme can work with companies through a range of collaborative mechanisms to:

- provide consultancy services where specific expertise is required
- work together with companies on projects funded either directly by the company or jointly with contributions from other funding sources
- manage medium and large scale research projects and programmes
- assist in commercialisation of new technologies
- develop multiparty research initiatives across NZ and overseas, to bring together the necessary expertise to develop new technologies
- provide links to international research expertise

A selection of Energy research theme projects

Improving the performance of wind farms using predictive load control

The aim of this project is to better understand and control the behaviour of wind turbines in a wind farm in response to changeable flow conditions.

In normal wind farm operation, each turbine in a farm has sensors to detect wind flow and a reactive controller which alters the turbine response appropriately. This means that existing controllers act only after loads have already been measured by its sensors and after fatigue damage has already occurred.

This project uses existing sensors on wind turbines in the entire wind farm to predict future inflow to downwind turbines. One of the challenges in this research is the ability to account for the vortices generated behind each turbine which have important effects on dynamic loads. Transient flow methods will be used to model fluctuations in wind direction and gust duration.

The project will enable development of technologies that will allow data from upwind turbines to be incorporated into turbine controllers to achieve early response to gusts and extreme wind events. This leads to a longer operating life, reduced downtime due to vibration induced faults, and increased effectiveness of wind farms.

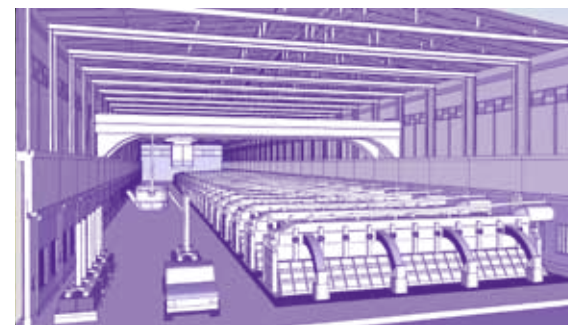


This project brings together expertise in transient flow modelling, computational fluid dynamics, real-time artificial neural networks and wind turbine control design.

Removing and recovering heat from aluminium smelting cells

In aluminium production, metal is produced in cells that operate at temperatures above 950°C. There is a delicate balancing act involved in managing the heat – enough energy needs to be supplied to keep the working fluid (electrolyte) in a liquid state, while at the same time removing heat from the cell exterior to ensure that the materials the cell is constructed from do not suffer heat damage. On top of this, modern smelters are required to operate at higher production rates, thus requiring more energy input and heat extraction, and are under increasing pressure to reduce their overall energy usage.

The Light Metals Research Centre has developed and patented the Shell Heat Exchanger cooling technology, that are compact and efficient air-driven heat exchangers capable of providing controlled cooling of smelter cell sidewalls. They allow peak shell temperature reductions of 50-100°C, which enables the operator to significantly increase amperage and hence productivity in the cell while retaining other operational



benefits, including a cooler operating cell and allowing waste heat recovery of 100-200 kW per cell. The goals are to enable smelters to increase production without the substantially increased capital cost of new cells and ultimately to recover energy.

Green energy

A wireless green energy system, which serves as a microgrid to power homes and cars, is being designed to harness and integrate renewable energy sources such as solar and wind.

Household renewable energy systems require a very large and expensive energy storage facility in addition to the cost of installing solar panels, wind turbines and associated electronics. The concept here is to use an electric vehicle, which already has a powerful battery, not just for mobility but also to supplement existing household energy storage as appropriate. The system, which also allows for the electric vehicle to be wirelessly charged or discharged, can easily be upgraded, and is expected to be appealing to consumers because of its versatility and improved financial viability compared to conventional hard-wired systems.

The first working model of the 'living and mobility' concept is currently being built, and includes new technologies being developed for bi-directional and wireless power transfer, grid integration and generator systems to improve both efficiency and performance of the overall system. In comparison to existing systems, it will be more cost effective, safer, versatile and scalable.

This project combines expertise in renewable energy, wireless power transfer, generator design and control, and power electronics, and is run in collaboration with many leading international universities. At present a team of ten researchers, comprising PhD/ME students and postdoctoral fellows, are working on various aspects of the project in relation to efficient energy management, wireless charging of electric vehicles, grid integration of induction generators and high power converters.



Electric power optimisation

In 2009, the New Zealand electricity market underwent close scrutiny. This resulted in the implementation of 21 new measures by October 2010 to improve the efficiency of the market. Some of these measures were changes in ownership of assets by the current generators.

Was the market functioning inefficiently?

Will the suggested asset swaps alleviate the diagnosed inefficiencies or will they introduce new inefficiencies?

Is it possible to have a properly functioning and efficient electricity market?

We work with various market participants, for example, generators, major consumers and distributors. Our research ranges from profit optimisation, under uncertainty, for these market participants, to designing optimal mechanisms for clearing the market.