NIWA
Taihoro Nukurangi

Climate-Energy Matters

a quarterly newsletter from the National Centre for Climate-Energy Solutions

Is there a future for coal in New Zealand?

Coal in New Zealand has a negative image. This is despite our economic reliance on it as a primary energy source, and the major role it plays in offering "dry year" energy security. In part this image is deserved – some old mine sites remain the same as when they closed many years ago. But this reputation results mostly from industry's failure to explain how it now operates – how coal is mined and how it is used with modern, clean technology.

Yet New Zealand has 150 000 PJ of economic coal reserves – equivalent to 15 Maui gas fields!

New Zealand industry, including some of our largest manufacturers, relies on coal as a cost-effective primary source of energy. In the past year, Solid Energy sold 36PJ (1.55 million tonnes) of coal in New Zealand; 45% for steel manufacturing, 22% for electricity generation at Huntly (New Zealand's only coal-fired power station), and the balance for dairy, timber, cement, meat, and industrial processing, and the health sector.

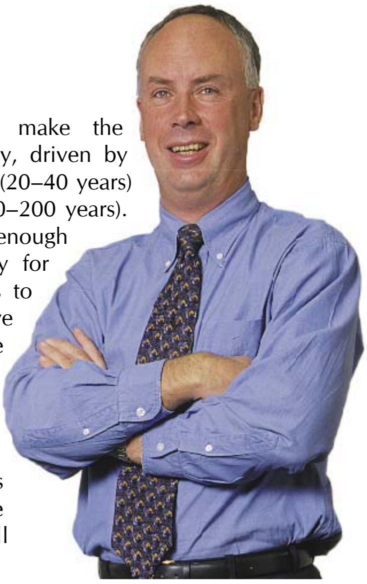
The key issue for New Zealand is "How can we best and most responsibly use coal to support the country's economic growth and competitiveness during our transition to a renewable energy economy over the next 100 years?"

As a small country with a small population, distant from international markets, New Zealand has relatively few economic advantages. However, New Zealand leads the world in implementing technology to harness the value in energy-intensive and energy-efficient primary product processing. The value added to the economy by the processing step is the only significant difference between our economy and that of most developing countries.

New Zealand's energy supply is still dominated by hydro for electricity generation, although almost every industrial manufacturer relies on coal or gas for direct energy. The direct use of this energy for processing is both highly efficient and cost effective. The ready availability of cheap Maui gas is a thing of the past, and, because major new hydroelectric schemes or nuclear power are unlikely, New Zealand's long-term energy future rests with either new energy forms or with coal.

Renewables, such as wind and solar power, and future possibilities such as hydrogen-powered fuel cells, are still very expensive, although they will become cheaper as technology advances. They offer long-term prospects, but in the short to medium term – 10–30 years or longer – are not feasible without a significant rise in the price of energy and the resulting economic impact.

New Zealand has 10 billion tonnes of economic coal reserves, and we are currently using only 4 million tonnes per annum.



The world will eventually make the transition to renewable energy, driven by declining oil and gas reserves (20–40 years) and the depletion of coal (100–200 years). However, New Zealand has enough coal to support the economy for over 1000 years, enabling us to maintain our core competitive advantages in energy-intensive primary product processing for export. Coal is already the lowest cost energy form for almost all industrial processing where cheap gas is not available, and it offers the lowest cost option for almost all new electricity generation.

But coal does need to improve its environmental credentials. Clean coal technologies, available and in development overseas, can increase the efficiency of coal-based electricity generation from 25–40% to more than 50%, with higher efficiencies targeted by international research and development programmes, leading to decreases in emissions per unit of energy produced by up to 50%. Pollutant emissions can already be reduced to near zero, and this ambitious target has also been set for programmes to reduce CO_2 emissions. Solid Energy is working with international researchers to ensure this technology is adaptable and suitable for New Zealand conditions.

With these initiatives, Solid Energy believes coal can and will fill its role as a key driver of New Zealand's economic growth for the next 20 years, and far beyond.

Dr Don Elder, Chief Executive,
Solid Energy New Zealand Ltd

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Greenhouse gases from residential energy use

New Zealand's intention to ratify the Kyoto Protocol means that during 2008–12 we will have to accept responsibility for any excess of greenhouse gas emissions over 1990 levels. This is based on the warming effect that greenhouse gases have on the earth's atmosphere. Our emissions have been increasing since 1990, so we either have to reduce them or use valuable forest-sink credits to offset them.

In New Zealand, energy derived from fossil fuels contributes significantly to greenhouse gas emissions, particularly carbon dioxide (CO$_2$). In 2000, the energy production and transport sectors' emissions accounted for over 90% of the gross anthropogenic CO$_2$ emissions, with the increasing use of natural gas in electricity generation and diesel and petrol for domestic transport being the two major contributors. However, it is difficult to appreciate how the average person or home contributes to the overall pool of greenhouse gas emissions through energy use. So let's take a look.

According to the Building Research Association of New Zealand (BRANZ), energy use in New Zealand homes is mainly met by electricity and natural gas. BRANZ estimates that on average a typical home consumes about 6700 kWh of electricity and 2400 kWh of gas each year. Although other sources, such as coal and wood, have direct CO$_2$ outputs, their use is small compared with gas and electricity.

CO$_2$ from natural gas use

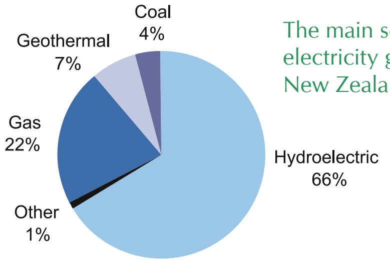
Most of the natural gas in New Zealand comes from the Maui field, and is mainly used for hot water heating in many North Island homes. When this gas is burnt to produce heat, it directly produces CO$_2$. The total amount of CO$_2$ produced from natural gas use in a typical house per year is:

2400 kWh/year/house = 0.008640 TJ/year/house
0.00864 TJ/year/house x Maui CO$_2$ emission factor (52.8 tonnes of CO$_2$/TJ)
= **460 kg of CO$_2$ per year per house.**

CO$_2$ from electricity use

Residential electricity use does not directly produce CO$_2$ in the home, but does result in emissions of CO$_2$ if the electricity is generated from fossil fuels at thermal power stations. If your electricity came solely from hydroelectricity, your residential emissions would effectively be zero. However, in reality the nature of New Zealand electricity generation and supply is more complicated. Therefore, one approach is to calculate CO$_2$ emissions based on the national share of different electricity generating sources. Based on data from 2001, the average New Zealand household emits about 450 kg of CO$_2$ per year from an average 6700kWh/year electricity use.

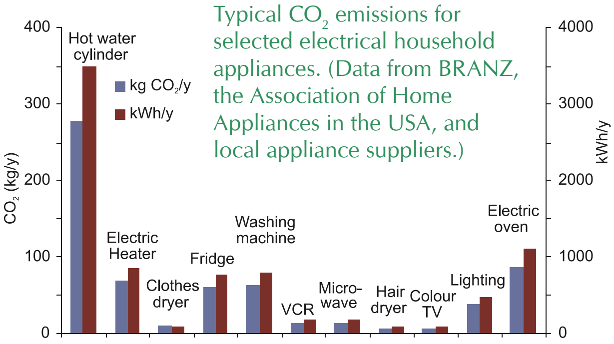
Incidentally, although hydroelectric power stations are not regarded as direct emitters of greenhouse gases, indirectly their construction and operations do produce CO$_2$ emissions.



The main sources of electricity generation in New Zealand (July 2001)

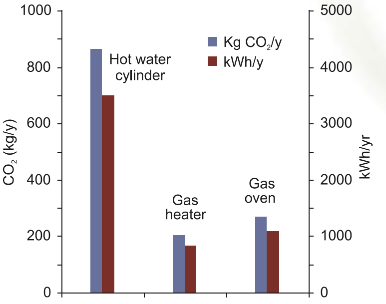
CO$_2$ from using household appliances

So where do most of the CO$_2$ emissions from electricity use come from in a typical household? There are often substantial variations between appliance models, and emissions are averaged over a range of models.



Typical CO$_2$ emissions for selected electrical household appliances. (Data from BRANZ, the Association of Home Appliances in the USA, and local appliance suppliers.)

Hot water heating is the single largest consumer of electricity in New Zealand homes and therefore the main source of CO$_2$ emissions. According to BRANZ, some 1000–1100 kWh/system/year is lost from freestanding hot water, which represents about 30% of the total CO$_2$ emitted from hot water heaters. Any energy efficiency improvements that can be made to this appliance alone will, therefore, result in significant energy savings as well as significant reductions in CO$_2$ emissions. Additionally, your choice of household energy significantly affects your share of CO$_2$ emissions, with similar energy consumption figures for electricity and gas producing 278 kg CO$_2$/y and 863 kg CO$_2$/y respectively.



Typical CO$_2$ emissions for selected gas household appliances.

Other "energy-needy" appliances such as ovens, refrigerators, and heaters also use a significant fraction of the total energy consumed by the average household and thus offer further targets for energy and CO$_2$ emissions savings. By comparison, an average car generates about 1000 kg of CO$_2$/year.

There is substantial potential for national savings in energy use and greenhouse gas emissions, and the average household has a major role to play.

Measure your own CO$_2$ emissions

A New Zealand web-based Residential CO$_2$ Calculator has been developed so you can measure your own CO$_2$ emissions. Simply select the appliance and estimate the amount of time it is used, and the calculator will tell you how much CO$_2$ you produce.

www.niwa.co.nz/ncces/co2calc

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Can farmers produce their own energy and reduce greenhouse gas emissions?

Biogas recovery could provide a free energy source to New Zealand's farmers and has the additional benefits of controlling odour release and reducing greenhouse gas emissions.

What is biogas?

Biogas is naturally generated by the anaerobic digestion of animal waste (e.g., dairy shed, piggery, and chicken farm wastes).

Biogas typically contains 70% methane and 30% carbon dioxide, although high concentrations of odorous gases such as hydrogen sulphide and volatile organic acids are produced if anaerobic digestion is incomplete.


NOAA

Both methane and CO_2 are greenhouse gases, but methane is twenty times more potent as a greenhouse gas than CO_2. Methane emissions are responsible for 20% of global warming since pre-industrial times, and the atmospheric concentration of methane is increasing by 1% annually.

Given the level of agriculture in New Zealand, capture and combustion of biogas from animal waste is a relatively simple and cost-effective way to reduce our methane emissions.

Biogas uses

Biogas has an energy content similar to that of natural gas and the technical feasibility of using biogas to generate electricity is well established (e.g., in rubbish dumps). However, biogas may also be used for gas-fired heating or refrigeration. Excess heat from generators and boilers can be circulated through a heat exchanger to improve the efficiency of anaerobic digestion.

On-farm methane recovery can significantly reduce energy bills by providing most, if not all, of the electricity, heating, or cooling required by the farm. Annual energy savings should be at least $2000 for a 300 cow dairy farm and $7000 for a 1000 cow farm. The use of the electricity generated from recovered methane will further offset the use of fossil fuels and their resultant greenhouse impacts.

The minimum farm size for economical methane recovery is about 300 cows or 500 pigs, and the technology becomes more cost-effective as farms increase in size and farming becomes more intensive.

Collection systems

There are three types of anaerobic treatment systems that are typically used to recover methane from animal waste: covered lagoons, complete mix digesters, and plug flow digesters. In all three systems the methane is captured by a gas-tight cover over the digester.

Covered lagoons

Anaerobic lagoons are economical and practical to design, and operate well in temperate climates. The manure is best handled as a liquid by flushing and may require solids separation to give a typical solids concentration of less than 2%. Anaerobic lagoons usually have a loading rate of at least 0.1 kg volatile solids/m^3/day.

Complete mix digesters

Anaerobic digesters are more efficient than covered lagoons because they are heated and mixed. The total solids concentration in the influent to sustain self heating must be at least 3%, and slurries of up to 8% solids are suitable. Therefore, the manure is best handled by scraping and is usually pretreated in a mixing tank where additional water or manure solids are added to obtain the optimal solids concentration. Loading rates and retention times are typically 1.2 kg volatile solids/m^3/day and 20 days respectively.

Plug flow digesters

Plug flow digesters are constant-volume, unmixed, controlled temperature digesters designed for dairy farms, where the manure is scraped and has a total solids concentration of more than 9%. Manure is pretreated in a mix tank before entering the digester. Manure fed into one end displaces an equal amount of manure from the other.

Anaerobic lagoons are already used to treat agricultural wastewaters on many farms in New Zealand, but very few are covered, and fewer still are for biogas collection. Covering existing anaerobic lagoons would therefore be the simplest and most cost-effective method of harnessing the biogas produced from the waste. Anaerobic lagoon covers cost $5–20 per square metre. However, the total cost of covering an anaerobic lagoon should be recovered through energy savings within 6 years.

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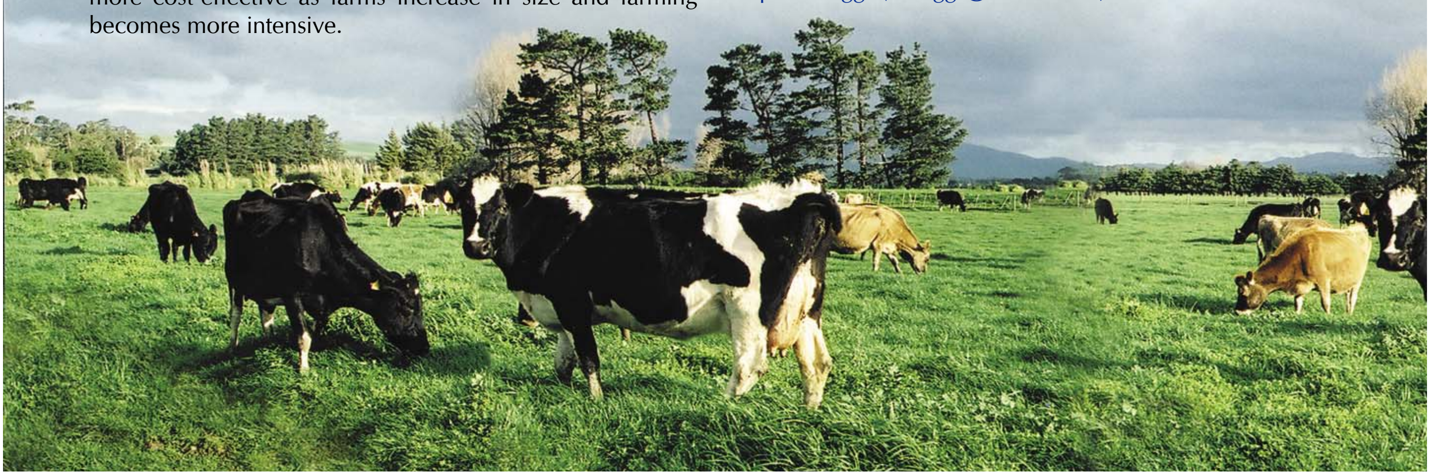

Where are our power cables?

Any standard map will show the locations of power pylons around New Zealand, but the exact position of the lines – how far above the ground or the trees – varies from hour to hour. The height of the cables can vary by several metres, depending on how hot they are, which in turn depends on how much current is flowing, and what the weather is like. It is important to understand this variation so that adequate separation is maintained between the lines and buildings, roads, or vegetation, and to avoid overheating by passing too much current through them.

A major Transpower survey, covering about one-third of its national high voltage transmission line network, was carried out to determine the precise location of the lines relative to the ground and vegetation, and to estimate the optimum current carrying capacity of the lines. A Russian company, Opten, which specialises in aerial laser surveying, carried out the helicopter-based survey. The exact position of the electrical conductors depends not only on the expansion due to heating from the electrical current, but also on heating by sunlight and cooling by the wind. So the weather needs to be known at every cable span as the survey helicopter passes. NIWA provided the meteorological support for the Opten survey.

The survey was carried out on 31 flying days over 6 weeks in late summer this year. More than 10 000 transmission line spans were surveyed, and a meteorological vertical profile had to be prepared for each span when the survey helicopter passed.

Twenty NIWA automatic weather stations were installed and removed at 140 sites between Auckland and Manapouri, and vertical profiles were measured by tethered balloon at 90 additional sites. Six NIWA field staff ensured that two, two-person teams were working 7 days a week through the whole period. The two NIWA support vehicles covered about 36 000 km.

The meteorological data collected from the automatic stations at intervals of 10 or 20 km along the survey route were sent each day to NIWA's Wellington laboratory at Greta Point as input for 3-dimensional meteorological modelling to generate the meteorological profile at six heights for each of the 10 000 cable spans. The model used, CALMET, from Earthtech in the USA, is a diagnostic model which generates the meteorology in three dimensions using any real data that have been collected, taking into account the effects of terrain and land use (e.g., forest, pasture, or lake), which can affect the wind fields. The effects of larger scale weather systems are also important, and CALMET includes larger scale, real and modelled, meteorological data in its input.

This level of meteorological support is greater than has previously been attempted for this type of survey anywhere in the world, and the meteorological modelling produced detailed and realistic results which will help Transpower supply electricity more effectively, and hence help New Zealand be more energy efficient.

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