The Need For New Electricity Generation – The Role Of Demand

Nigel Isaacs, Principal Scientist, BRANZ Ltd.

Introduction

The debate over New Zealand's need for more energy has ranged widely over the past few years but there seem to be some common themes:

- there is an urgent need for more electricity generation and transmission
- all possible ways of producing large amounts of electricity must be explored, whether commercial (e.g. wind or geothermal), existing but under development (e.g. nuclear) or in early (e.g. 'clean coal') or developed research (e.g. biomass or marine).

This paper explores how households use energy and concludes that the real issue is not more electricity generation, but rather the best way to match our fuel resources to our energy needs.

Fuels and energy

The focus of New Zealand's recent energy debate has been on electricity. Electricity is **a** very important fuel, but it is **not** the only fuel. 'Energy' and 'fuel' are different – fuel transports energy, but needs to be transformed to be useful. For example, the burning of coal (fuel) releases heat (energy). Uniquely, electricity is both fuel and energy – it can be transformed into heat or used directly (e.g. for a computer).

'Energy' can be thought of in terms of what it does – the 'end-uses'. To boil water, heat to reach 100°C is needed; to cook a cake needs heat over 100°C; while electronics need electricity. Heat can be provided by a wide range of fuels – natural gas, electricity, LPG, wood, coal, oil, geothermal or even the sun. Electricity can be generated from an even wider range of sources e.g. from fuels used in a thermal power station, falling water etc.

But is the real question: "What fuel is necessary to provide the desired energy services"? The results of the Household Energy End-use Project (HEEP) can be used to help answer this question (for more information on HEEP see www.branz.co.nz).

Household fuels

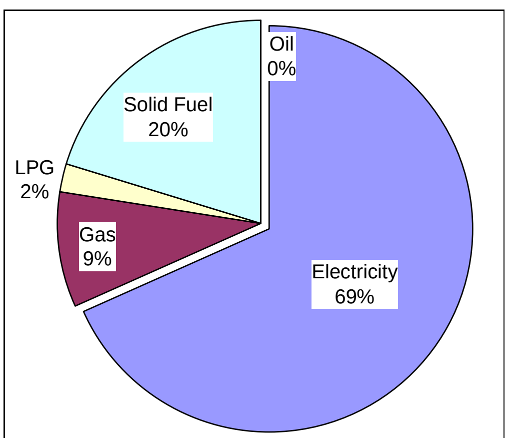

Figure 1: Household fuel use

The HEEP research monitored fuel and energy services in a statistically representative sample of 400 randomly selected houses from Invercargill to Kaikohe. In each house all fuels (natural gas, electricity, wood, coal, solar water heaters, oil and LPG) were monitored for a year. Energy services, such as living room and master bedroom temperatures, appliance and hot water use were also monitored.

The HEEP household fuel breakdown is given in Figure 1, showing that electricity is the major fuel in our houses. Before HEEP, the residential use of solid fuel (wood and coal) was not well known. HEEP knowledge has resulted in the addition of a 530 MW power station worth of wood to the official energy statistics – about half the size of the Huntly Power Station. But what are these fuels used for?

Household energy services

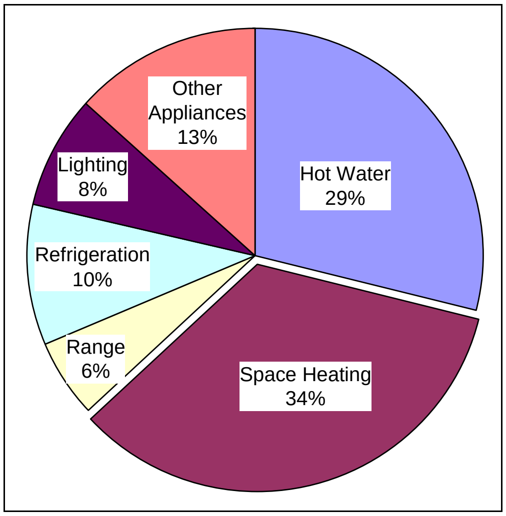

Figure 2: Household energy uses

Figure 2 shows the distribution of energy uses or services. Space heating and hot water are the largest uses, while appliances, refrigeration, lighting and cooking (range) account for the rest.

Another way to look at Figure 2 is that space and water heating (63%) need heat under 100°C, while the range (6%) needs heat over 100°C. Electricity-only services are 31%.

HEEP data reveals that the hot water fuels are electricity (75%), gas (20%) and solid fuel wetbacks (5%). The main space heating fuels are solid fuel (56%) and electricity (24%). Hence electricity generates a large amount of the under 100°C heat.

But what if household fuel use shifted from its current pattern into patterns that better matched the energy services? At least two extreme scenarios are possible:

- electricity was used only for electricity-only services (31% from Figure 2)
- electricity was used for all services (100% from Figure 2).

Shifting fuel use

Figures 1 and 2 are based on average energy use over the whole year, but energy use varies by season – space heating is mainly a winter energy use. The HEEP data shows the highest energy (and electricity) consumption is in July (winter) while the lowest is in January (summer). Table 1 gives the results for the present situation and the two scenarios:

- **present** – the energy used by New Zealand houses based on the current mix of fuels
- **electricity+gas** – electricity-only services are provided by electricity, while natural gas provides space and water heating, range
- **all electricity** – electricity is used to provide all services, with heat pumps with a Coefficient of Performance (COP) of 2.5 providing hot water and space heating.

HEEP results are presented as 'average Watts' – that is the power load if that fuel or service was being used for 8760 hours over a year. This avoids problems with different numbers of days in a month, or conversion between different energy units.

Table 1 shows that shifting to the **electricity+gas** scenario results in higher household energy use, while the **all electricity** scenario leads to lower household energy use. But just focusing on energy efficiency disguises the broader impact on the electric system.

Scenario season	**Present**	**Electricity + gas**	**All electricity**
Summer electricity	667 W	326 W	520 W
Summer gas or other heat fuel	81 W	503 W	-
TOTAL household energy	**748 W**	**829 W**	**520 W**
Winter electricity	1159 W	506 W	1086 W
Winter gas or other heat fuel	1050 W	1671 W	-
TOTAL household energy	**2209 W**	**2177 W**	**1086 W**
Winter:summer electricity ratio	174%	155%	209%

Table 1: 'What if?' residential energy scenarios

Table 1 also shows the present summer household electric load averages 667 W. Shifting water and space heating (**electricity+gas**) to natural gas reduces the average household electric load by 51% to 326 W. Shifting to high efficiency electric heat pumps (**all electricity**) reduces the average summer electric load by 22% from 667 W to 520 W.

E-mail: NigelIsaacs@branz.co.nz

In winter the impacts are more pronounced, as space heating plays a larger role. The **electricity+gas** scenario reduces the average winter electric load by 56% from 1159 W to 506 W, while the **all electricity** scenario results in a very small reduction of 6% to 1086 W.

The relationship between the winter and summer electricity load is also important. The closer the electric loads during the two seasons (i.e. closer to 100%) then the lower the need for costly peak electricity generation plant. The current average winter (July) load is 174% of the summer (January) load. Shifting space and water heating to natural gas reduces the ratio to 155%, as well as reducing the winter electricity demand. Using high efficiency electricity heating increases the peak to 209%, but maintains the present winter electricity demand.

Today about 80% of households have electric resistance hot water, reducing the impact of the **all electricity** scenario. Leaving hot water fuels unchanged (but using heat pumps for space heating) reduces the average summer load by 4%, increases winter load by 7% and increases the winter to summer electric ratio to 194% – resulting in a greater need for peak generation.

This moving of space and water heating to high efficiency electricity results in an almost unchanged electricity load with an increase in the 'peakiness' of the winter monthly (and most likely daily) load. This also holds true if only space heating is converted to heat pumps.

Resource implications

Any suggestion for more gas use raises concerns about gas reserves. In 2005 the residential sector consumed 6.5 PJ, or about 5% of total gas use. 68% of gas was used for electricity production and non-energy purposes. The increased direct use of gas under the **electricity+gas** scenario would not appear to be a major resource issue. Electricity generation in the **all electricity** scenario could use natural gas, but would require more than the **electricity+gas** scenario. Coal-fired generation would further increase carbon emissions. Alternatively, the household use of wood would reduce carbon emissions, but would need high efficiency burners to minimise local air pollution.

Each of these scenarios has generation, transmission, distribution, environmental and greenhouse gas implications. Of particular note are New Zealand's obligations under the Kyoto Protocol (which would be best served by lower greenhouse gas emissions), and local air pollution problems (which require the use of low emission residential scale burners).

Conclusions

New HEEP knowledge of energy use in New Zealand homes has allowed the use of two scenarios to explore the impact of encouraging the use of higher efficiency electric space and water heating. Shifting from current space heating fuels (about half of which are wood or coal) to electric heat pump based space and water heating adds a significant load to the electricity generation, transmission and distribution system. Heating fuels (e.g. natural gas, wood or coal) used directly in an efficient burner reduce the load on the electricity system, notably by reducing the baseload and the winter peak, and ultimately need less generation.

No attempt has been made in this analysis to account for changes in occupant behaviour (such as the use of the heat pumps for summer cooling), improved efficiency in the use of natural gas or solid fuels, availability of natural gas in the South Island, or any energy efficiency improvement of buildings or plant, beyond the use of heat pumps. Capital implications have also not been considered – whether for new generation, transmission, distribution or on-site equipment. These, and many other questions, should form the basis for a more detailed study.

Most importantly, this analysis shows that the real debate is not about the most desirable way to generate electricity or build transmission lines, but rather what is the best way to use our many different, abundant fuels.