Fuel Poverty in New Zealand

Abstract
The concept of fuel poverty emanated out of grass roots environmental health movements in the UK in the early 1980s. In recent years it has been taken on board by the UK Government in as much as they have committed to eradicate it by the middle of this decade. A household is in fuel poverty if it would need to spend more than 10% of the total household income on all household fuels to achieve a satisfactory indoor environment. The satisfactory indoor environment is defined as being at temperatures of at least 21 degrees Celsius in the living areas and 18 degrees Celsius in other parts of the house. The number of households in fuel poverty in the UK has been variously estimated at somewhere between one million and seven million with a median acknowledged by the Government of around three million in 2001. This number would mean some 14% of the population in the UK was in fuel poverty at that time. The present paper suggests that in NZ the number of households in fuel poverty in 2001, using the same definition of adequate indoor temperatures as for the UK, is very similar, with a range of between 10% and 14% of the total households.

Background
Fuel poverty is a concept that arose out of grass roots energy action groups in the UK and Ireland during the early 1980s. This was a time when the oil price hikes of 1974 and 1979 produced fuel cost increases which in turn led to large heating bills for residential consumers. The poorer consumers suffered more than others in terms of having to pay a larger percentage of their total income to keep warm.

The first definition of the concept was a fuzzy notion: "*The inability to afford adequate warmth in the home*" as given by Lewis in a submission for the National Right to Fuel Campaign in Bradford UK (Lewis1982). Later, Brenda Boardman, in her doctoral thesis and her groundbreaking book on fuel poverty (Boardman 1991) expanded the concept to include the effect of energy inefficient housing. The idea was roughly that households which would need to spend more than 10% of their income on all household energy fuels in order to achieve a satisfactory indoor heating regime were categorized to be in a state of fuel poverty (Clinch and Healy 2001). The key idea here is that the fuel cost is attributed to what they would need to spend, not what they actually spend. The early definitions lacked precision both in terms of adequate economic parameters and in terms of the thermal parameters. Even today the definition is debated both in terms of what constitutes an adequate thermal environment and what constitutes the total household income. Despite the definitional debates, fuel poverty has been taken on board by the UK government in their current strategy to combat the health effects associated with cold homes (DEFRA 2001). The problem in the UK has been particularly politically sensitive due to historical poor levels of housing quality and their nearness to better housed and cooler northern neighbors.

Household fuel poverty is currently defined in Britain (DEFRA 2003) as the need to spend more than 10 per cent of annual household income on ALL household fuel use. The heating fuel component of the household fuel use should be sufficient to enable the home to achieve a satisfactory heating regime (see below). The household energy use excludes transport, lawn mowers, boats and other recreational energy use not specific to that used within the residential building itself.

The UK definition assumes that a satisfactory heating regime is one where the main living area is at 21°C, with 18°C in other occupied rooms. It is assumed that heating is available for 16 hours per day for households likely to have occupants home all day, and 9 hours per day for households in work or full time education. It is also assumed that the whole house is

heated except where the household is "under-occupied", when it is assumed that half of the house is heated (DEFRA 2003). This characterization is consistent with the WHO recommendations on adequate indoor temperatures (WHO 1989). Under-occupied, in the UK context, implies that the house has more than one unoccupied bed room.

In Australia, which has a much warmer climate than either the UK or New Zealand, fuel poverty was investigated in the 1980s and was the subject of a number of research reports, including *Fuel Poverty in Victoria* (Energy Action 2002) and *Unequal Access* (Backman et. al. 1987). Due to the deregulation of the electricity sector in Australia and rising prices especially in the more remote areas of the country the problem has been recently resurrected with lobby groups again questioning how market deregulation can sit with the provision of social equity (Energy Action 2002).

The economic parameters dealing with the UK definition of household incomes are difficult to translate internationally, so is best considered in terms of current national definitions. In this context the household income is the income as reported by Statistics NZ. Fuel poverty is commonly applied to developed countries and to cool climates that need heating for part (or all) of the year, however, it has also been considered in terms of warm climates (cooling energy) and in developing countries with regards to the provision of fuel for cooking. In this paper the concept is considered in terms of developed countries and for housing in cool climates, with Dunedin as a case study.

In terms of policy initiatives in NZ, reducing fuel poverty is consistent with the Ministry of Social Development (NZ) aims as given in their recent Statement of Intents 2005, among which are to: "*improve the overall wellbeing of New Zealanders. One way in which we do this is to reduce the inequalities experienced by disadvantaged groups. To be successful our work in reducing inequalities must focus on achieving sustainable improvements*". Households that need to spend more than 10% of their income on fuels to keep warm and to service an adequate lifestyle would be deemed in most developed countries to be disadvantaged. The emphasis on sustainable improvements will be examined again at the end of this paper.

In addition fuel poverty was discussed in the recent Sustainable Energy policy document produced by the NZ Ministry of Economic Development (MED October 2004). Unfortunately this document gives a misleading interpretation of the UK definition, as it refers to what New Zealanders *actually* spend on *heating* energy, rather than what they *would need to* spend on *all* household energy sources; in doing so achieving an adequate thermal environment (see earlier definition).

A recent International Energy Agency (IEA) report (Schipper, et al, 2000) suggested that: "By 1995 New Zealand had the lowest space heating intensity (measured as energy per square meter per degree day) of all the countries studied, even including Japan and was about half of Australian levels." The report continued: "It seems unlikely in practice that comfort levels are so low in New Zealand. Possible data problems with wood may partly explain this apparent discrepancy". The data they used are correct and comfort levels are indeed low. Residential energy use in New Zealand for 1995 was around 17 GJ/capita/annum compared to around 35 GJ/capita/annum in Australia, 30 GJ/capita/annum in Europe and 54 GJ/capita/annum in the US.

The low values for NZ residential energy use reflect low levels of space heating. Houses in NZ are 'energy efficient' in the respect that they use little energy, but poorly heated. In addition with the population being mostly located in the north of the North Island the national average does not reflect conditions in the south, which has considerably greater house heating

needs. For example, Auckland has around 1,150 heating degree days compared to Christchurch at 2,400, Dunedin at 2,600 and Invercargill at 3,000 degree days (the base temperature used is 18 $^{\circ}$C).

Method

The main difficulty in estimating the level of fuel poverty in a country relates to obtaining data on the thermal efficiency of residential housing and the corresponding heating necessary to meet the UK fuel poverty definitions (as given above). The energy needed to maintain adequate indoor temperatures is of course highly dependent on the, climate and the overall energy efficiency (including orientation and solar access) and size of the house. As the target group are the poorer sections of the community, the type of housing can be narrowed to that occupied by such socio- economic groups.

To this extent we have modelled a typical 90 m^2, 3 bedroom brick veneer house, as rented by Housing New Zealand to the public housing sector. The modelled house had a tiled roof and a suspended wooden floor with a window area of 25 m^2. This type of house has been monitored extensively as part of a concurrent research program to determine the efficacy of energy efficiency upgrades being undertaken by the New Zealand Government (Lloyd and Shen 2004). The building was modelled in different orientations but no solar shading from external buildings or the topography was included.

The thermal modelling was undertaken using a commercial package marketed by a Scottish company as "Virtual Environment". Verification of the model against actual temperature has been documented in an earlier paper (Taylor and Lloyd 2004). The modelling was undertaken initially for the Dunedin climate, which has an annual average ambient temperature of 11 ^{o}C. For the indoor environment we used the UK definition of an adequate indoor temperature regime (21 degrees in the living area and 18 degrees elsewhere in the house). The analysis was then extended to other population centres in NZ using the standard climate files as provided by the software vendor. These files were checked to ensure consistency with data from the National Institute for Water and Atmospheric Research (NIWA).

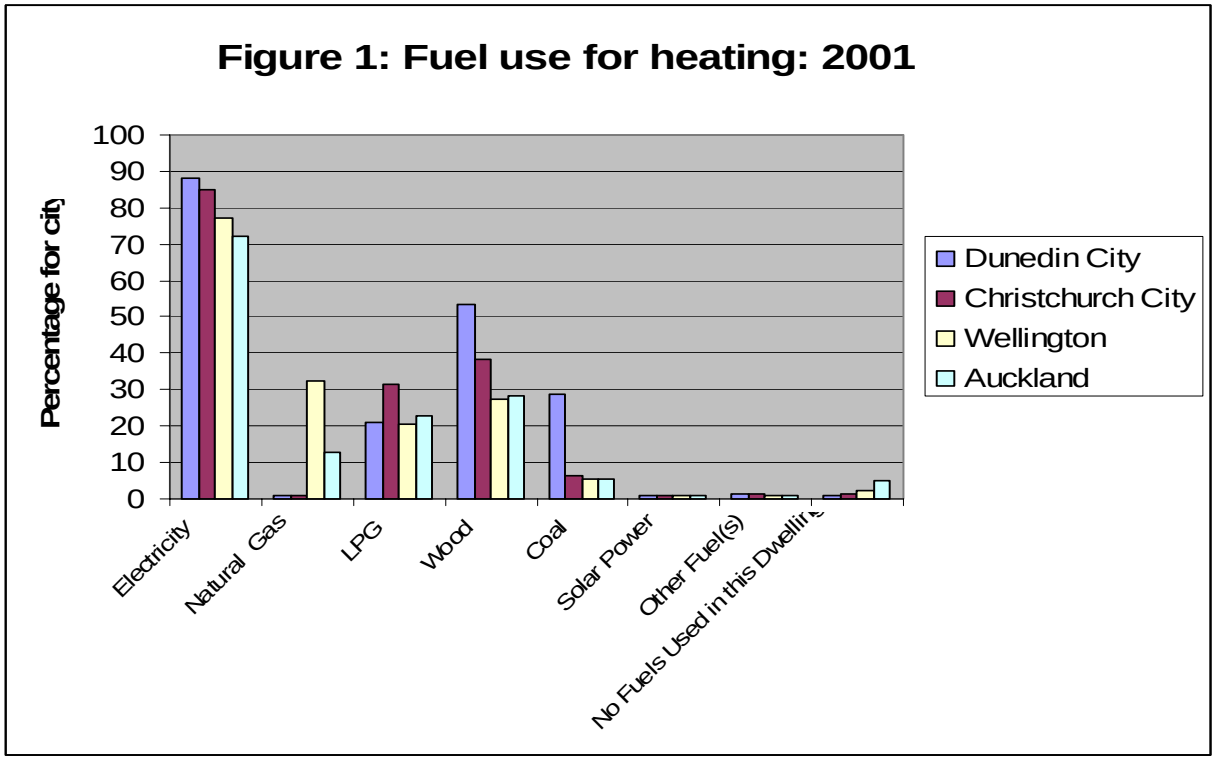
In terms of thermal insulation, the modelling was completed for both working occupants and unemployed occupants. A range of building fabric scenarios were modelled including the house not being insulated at all, to it being insulated to the level of the upgrade undertaken by Housing NZ (ie an overall R value in the ceiling of R4.0 but no insulation in the walls). The same heating time definitions as used in the UK definition were applied; that is 16 hours per day for occupants at home all week and 9 hours for working occupants. An occupancy level of 2.8 occupants per household was used and an air change rate of 1 air change per hour. Such housing and conditions would be typical for low-cost housing in Dunedin.

Statistics on income and energy use for the residential sector in NZ were obtained from the national data gathering organisation, Statistics NZ and from the Ministry of Economic Development (Statistics NZ 2004, Energy Data File 2004). For the present research these data were obtained a regional level with some aggregation to a city level. To enable the percentage of households below a give income level to be calculated, the income data are plotted against the accumulated percentage of households. This curve was then modelled using a polynomial and the data interpolated to give the required percentage.

Results

While the data needed to estimate the amount of heating needed to achieve an adequate indoor thermal environment (UK definition) does not depend on the amount of heating actually used, it is necessary to know the types of heating used so that cost data can be estimated.

Data from the 1996 and 2001 census provides an outline of the fuel types used for New Zealand domestic heating. Although there has been a slight decrease in the number of houses using electricity from 1996 to 2001 it is still the major means of home heating. It is important to note that both electrical resistance heating and heat pump systems fall into this category although they have a factor of three difference in heating efficiency. In contrast to electric heating the use of gas (natural or LPG) has increased slightly from 1996 to 2001 while wood consumption has remained relatively stable. Figure 1 shows the fuel type data for 2001 as obtained from Statistics New Zealand.



As can be seen the most common form of space heating is electricity, mainly in the form of resistance heating. No data could be found on the numbers of heat pumps used for space heating in the domestic sector in NZ but the numbers are likely to be very small in low-cost housing due to the high capital cost of the units. In our concurrent study of energy use in Housing NZ homes no heat pumps were found other than in demonstration sites.

The 2001 Household Income Study revealed that nationwide 88% of households used electricity for house heating (Statistics NZ). The average consumption of electricity (all uses) for a Dunedin house is 9417 kWh per annum. This is based on data from 9664 houses in Dunedin City over the period of June 2002 to May 2003 and has been provided by one of the electricity power supply companies (Trust Power 2003). The national average consumption is 20% lower at around 7800 kWh per household per annum (Energy Data File 2003 for the year 2002). Our own data for the electricity consumption for the low-income sample (111 houses investigated in the Housing NZ upgrade program were close to the average for NZ at 7,700 kWh/household/annum (±360kWh/household/annum).

The Building Research Association of New Zealand (BRANZ) is in the midst of a comprehensive Housing Energy Efficiency Project (HEEP) study which is investigating energy use in residential housing nationally. This study has found that nationally only

between 20-30% of electricity and natural gas goes to space heating in NZ (HEEP year 7 report 2003). These figures, however, exclude LPG and solid fuel heaters and include only Christchurch as a representative site in the South Island. Disregarding the exclusions, the share used for space heating would mean around 2800 kWh/household/annum is presently used on average for house heating in Dunedin (electricity and LPG only). This value for space heating agrees well with our own data gathered for the Housing NZ upgrade survey. The data gave the seasonal component of electricity use (ie mostly space heating) of around 2,400 kWh per annum.

National statistics (Energy Data File 2003) attributes only 69% of residential energy use to electricity with the remainder being taken up by natural gas, wood, geothermal, LPG and coal as shown in Figure 2. This amounts to a national average of 11,600 kWh/household/annum (15GJ/capita/annum at 2.8 persons per household) for all energy use. This is slightly lower than the IEA value of 17 GJ/capita per annum probably due to the national statistics not accounting fully for non-commercial wood fuel usage. The 2001 Housing and Incomes survey (Statistics NZ) found that $1246 was spent per household per annum on average for all household energy fuels.

The non-electricity fuels would be used predominantly for space heating (although some gas for cooking and water heating). The data from our low-income Housing NZ houses indicated a value for total (net) household energy use (sample size 111 houses) for Dunedin at 9,600 kWh/household/annum (±510 kWh/household/annum). The net heating calculations used 100% thermal efficiency for electric and un-flued gas heating, 60% for solid fuel burners and 15% for solid fuel burnt in open fires. The gross energy used for he same sample, however, would be closer to 11,000 kWh/household/annum and thus just under the national average energy use as determined from the values in the 2003 Energy Data File. This agreement would suggest that in Dunedin for the poorer sections of the community the total net energy used for space heating would be between 3,800 kWh/household/annum (2,400 kWh electricity and 1,400 kWh other fuels) and 4,300 kWh/household/annum (2,400kWh/household/annum electricity and 1,900 kWh/household/annum other fuels).

The fuel actually used by households, however, is irrelevant to calculate the numbers that may be subject to fuel poverty as the definition is framed in terms of reaching the adequate indoor temperatures. The energy needed to maintain the adequate temperatures, as defined by the UK definition, was obtained by modelling the typical 90 m^2, 3 bedroom brick veneer house for a range of installed insulation options and occupancies. This modelling suggested that the space heating energy necessary to achieve the adequate thermal environment would be between 13,000 kWh and 16,000 kWh/household/annum for houses located in Dunedin. The lower value is for 9 hours heating and R4 insulation in the ceiling. The higher value is for 16 hour heating and no insulation in the walls or ceiling. Other scenarios fell in between the lower and upper space heating values given above.

At electricity retail rates of 9.5 cents per kWh (2001 prices– from the 2003 Energy Data File including GST) the heating regime necessary to secure adequate indoor temperatures, that is space heating of between 13,000 kWh/household/annum and 16,000 kWh/household/annum would cost between $1240 and $1500 /household/annum. The cost of LPG in Dunedin was similar to electricity at 8.9 cents per kWh (2001 prices from 2003 Energy Data File including GST). Then adding in the cost of the remainder of the electricity bill being 6600 kWh/household/annum, or $630/household/annum, for water heating and other demands, this would give a total annual energy cost to the household of between $1,900 and $2,100 (resistive electric heating or LPG heating).

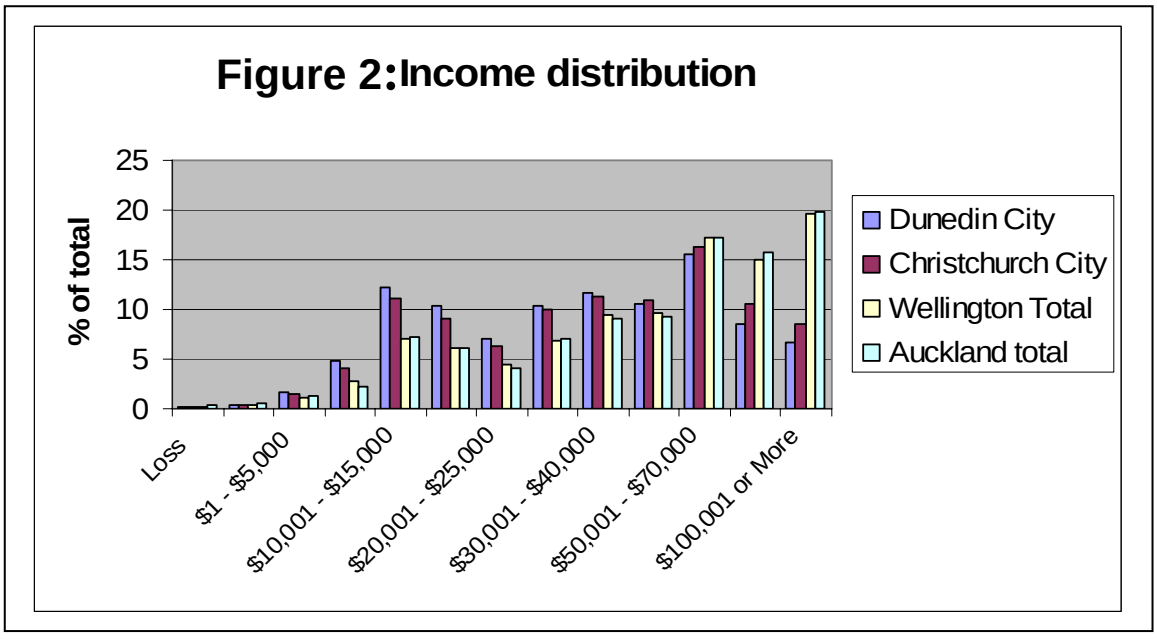
A household would then be deemed to be in a condition of fuel poverty if the total household earnings were below between $19,000 and $21,000 per annum (electricity and gas only).

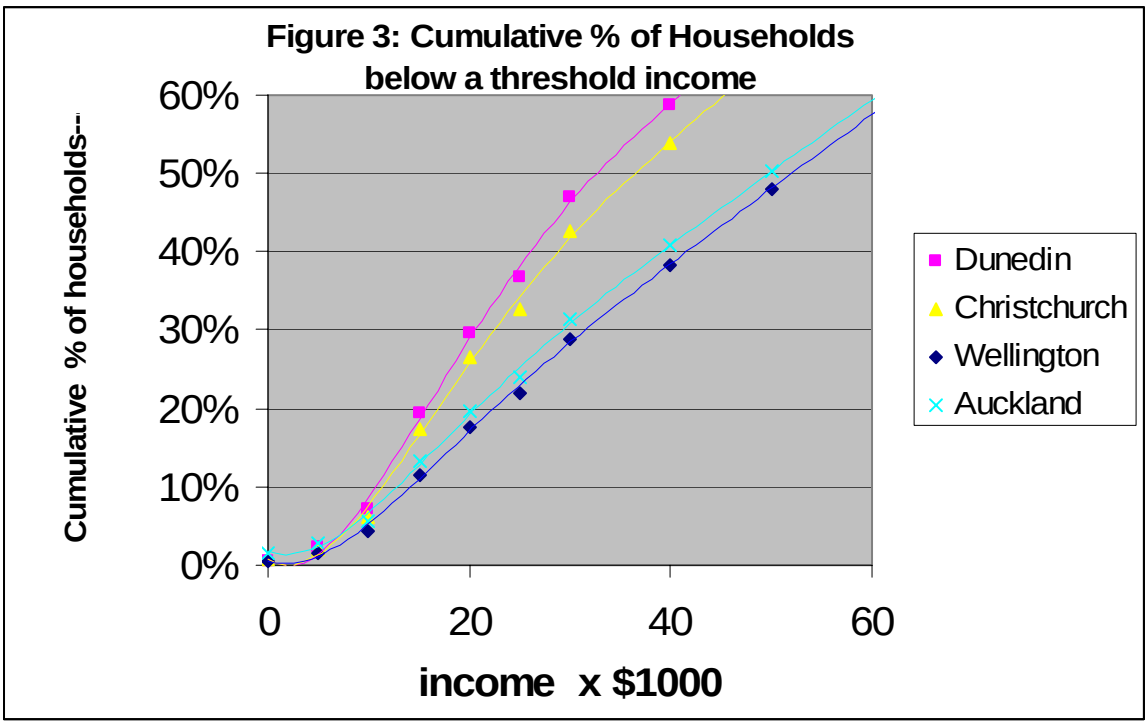
The average income of people in Dunedin (2001) was somewhat lower than the national average; that is an average annual income of $14,500 per person compared to $18,500 per person nationally. (Otago $15,700 per person: 2001 data, source Statistics NZ). In terms of households, Figure 2 gives the breakdown for Dunedin. It might be noted, however, in this context that one of the reasons for the relatively low-income of people in Dunedin is due to the high proportion of a low-earning student population. Dunedin is a university town with a student population as high as 20% of the total resident population.

From these data it can be seen that in 2001 around 30% of households in Dunedin (that is those which generate less than $20,000 income per household per annum) would be highly likely to be in a situation of fuel poverty. To repeat, this assumes that the house is heated adequately to the UK criteria for fuel poverty. The HEEP study (BRANZ 2003) and our own study of public housing (Lloyd et. al. 2004) , however, made it clear that houses in Dunedin are not heated adequately and that temperatures considerably lower than WHO recommended levels are routinely experienced at all income levels. In Dunedin the estimated fuel used (for space heating only) for low-income families as surveyed in our sample of 111 Housing New Zealand homes was closer to 4000 kWh/household/annum or 27% of that needed to maintain an adequate indoor thermal environment, as defined by the UK definition.

The same 90 m^2 brick veneer house was also modelled using the climate (including the same range of insulation levels and various orientations) for the other main centres in NZ. The energy needed reduced considerably as the location moved further north as given in table 1.

The household income distributions for the other centres are also shown in Figure 2 and were again obtained from Statistics NZ. The percentage of households earning below a given dollar income was obtained by interpolation from graphs analysing cumulative percentages of households below a threshold income as given in figure 3.





The results of this analysis are given in Table 1. Here, the Auckland data are for the five territorial authorities North Shore City, Waitakere City, Auckland City, Manakau City and Papakura City. Wellington comprises: Porirua City, Upper Hutt City, Lower Hutt City and Wellington City. The total number of households likely to be in fuel poverty comes to between 65,000 and 89,000 or between 10% and 14% of the total population of the 4 main centres; which includes just under half (47%) of the total population of NZ.

Table 1: Fuel poverty for NZ households in 2001

	Heating energy needed kWh/y	Other electricity kWh/y*	Total energy cost @ 9.5c/kWh	Income thresholds	% of city population in potential fuel poverty	# households 2001	# households in potential fuel poverty 2001
Auckland	4000-6000	5,500	$900-$1100	$9,000 $11,000	6%-8%	348639	21,000-28,000
Wellington	8000-13,000	5,900	$1300-$1800	$13,000 $18,000	9%-14%	123975	11,000-17,000
Christchurch	11,000-15,000	6,200	$1600-$2000	$16,000 $20,000	18%-25%	121824	22,000-30,000
Dunedin	13,000-16,000	6,600	$1850-$2150	$18,500 $21,500	26%-32%	43290	11,000-14,000
Total					10%-14%	637728	65,000-89,000

* The higher costs for cooler climates reflect higher losses for hot water heating

If the pattern is followed for the regions outside the main centres, as it well might because the rural areas in general have lower incomes than the main centres and follow a similar climate profile, then the analysis would suggest between 10% and 14% of the country's households, or some 400,000 people, could be in fuel poverty nationwide. It is likely that this estimate is in fact on the low side for several reasons, including that the modelling is based on a 90m^2 house, which is at the small end of the housing market and assumes no solar shading. Dunedin in particular is afflicted with generally poor solar access (as is Wellington) due to the local geography. The average size of new housing has been rising in NZ from 127 m^2 in 1997 to 175 m^2 in 2003 (Statistics NZ). On the other hand the average number of residents has been

dropping from 3.2 persons per dwelling in 1997 to 2.7 persons per dwelling by the end of 2004. The use of lower cost fuels such as wood or coal on the other hand could lower the percentage of persons in fuel poverty.

Discussion

The figure of 10-14 % in fuel poverty for NZ is very similar to that estimated for the UK, where according to the (UK) government in 2001 some 3 million households or 14 % of the population (2001) were deemed to be in fuel poverty (DEFRA 2004). In Australia, Richardson et al, in their 2002 paper on the subject, conclude that for South Australia and Australia: "*for lower income households, the typical share of fuel costs in total disposable income in South Australia (and Australia) is a little over 4 per cent*." (Richardson et al 2002) This would mean that almost no households would be in fuel poverty (in the UK sense) in Australia, although these authors used fuel definitions and disposable income definitions somewhat different to the UK definition.

There are several strategies that can ameliorate the inequalities introduced by having a serious proportion of the population in a state of fuel poverty, including regulation of supply costs, improving housing insulation levels and or introducing specific subsidies to low-income households to pay some of the fuel costs.

Policy initiatives such as keeping electricity and other fuel costs low by regulation, however, would work across income levels and not necessarily reduce inequalities. In addition the NZ Government has had an overall aversion to domestic commodity subsidies as they tend to distort the market and make substitution difficult to achieve. Indeed the long-term historic low-cost of electricity in NZ, which in the days of a vertically integrated electricity sector provided a tax payer subsidized product, most likely contributed substantially to the relatively poor thermal housing standards in NZ. This situation occurred as energy efficient improvements in the residential sector would not be cost effective compared with cheap electric heating. In recent years as the deregulation has evolved in the electricity supply sector, the supposedly self-regulating industry has not worked well, especially with regards to security of supply. To remedy some of the supply side problems the Government introduced a regulatory authority, the Electricity Commission, in 2004 to assist in the long-term provision of electrical energy to the country. The terms of reference for this commission, however, have been centred on security of supply and sustaining economic growth, including providing an electricity supply system that "*is reliable: and resilient, is environmentally responsible, delivers energy prices that are efficient, fair, and as competitive as possible consistent with these requirements"* (Electricity Commission 2004) .

The emphasis on economic growth, fair and efficient pricing have been attacked by social action groups such as the Association of Citizens Advice Bureaux (sic) who submitted to an earlier version of the policy statement, that: "*there are some key parts missing from the Statement. Specifically we consider the Statement should address issues around electricity as an essential service, vulnerable customers and their inability to pay for electricity, and fuel poverty*"(Association of Citizens Advice Bureaux 2003). This concern was not addressed to any extent in the final policy document other than provision for a low-energy tariff for low-energy users. In addition recent increases in electricity prices (since 2001) almost certainly mean that the percentages in fuel poverty in NZ are somewhat higher than those given for 2001 and will continue to rise as energy cost increases outpace income rises. Price control of other non-electricity energy supplies would have similar market distorting difficulties that electricity price regulation would give.

In terms of improving household insulation levels, this strategy is a Government policy initiative included in the National Energy Efficiency and Conservation Strategy (NEECS 2001) which is being administered by the Energy Efficiency and Conservation Authority of NZ (EECA). As part of this program a subsidy scheme is directed at low-income households, but the initiative relies on the householder, or organization representing the householder, making a substantial contribution to the insulation upgrade. Another initiative in the same vein is being undertaken by Housing NZ, which has been upgrading state owned houses since 2001. However, strategies to combat the problem of high space heating costs by housing insulation upgrades targeted on mainly introducing ceiling and under floor insulation, may not producing improvements in indoor temperatures sufficient to satisfy health criteria (Lloyd and Shen 2004). This latter study of ours shows that in the southern South Island of NZ at least, many state owned houses still exhibit temperatures seriously below WHO recommended levels. Improving the thermal standard of houses is thus difficult especially in terms of retrofitting to existing houses. In addition research completed by a student associated with the Wellington School of Medicine, Gabrielle Davie, found that the level of seasonal mortality in NZ has not declined over the 20 years from 1980 to 2000, despite the introduction of thermal building standards requiring mandatory insulation levels, in all homes built after 1978 (Davie 2004).

The question of how poor housing affects health in NZ, especially in terms of older inhabitants, has been extensively discussed by researchers from the Wellington School of Medicine (Howden-Chapman et al. 1999). These researches address fuel poverty in terms of suggesting policies that will "*improve the thermal performance of houses, especially existing ones, that address the cost of power for older people, and that result in the education of older people about the risks of cold homes*".

Thus after considering and rejecting price control on energy supply and realizing the difficulties and time that will be needed to improve the housing stock, at least in the short to medium term, we are left with the final policy alternative, that of selective subsidies. This strategy has the advantage that it could be targeted at low-income householders and could be specifically related to the climate zone and the thermal condition of the housing occupied.

Finally it is thought that the relatively low-cost strategy of providing information to vulnerable groups, especially the elderly, as to the health aspects of being exposed to low-temperature environments, has not been attacked aggressively enough by any NZ Government health initiatives.

Conclusions

Our analysis of fuel poverty in NZ shows that the extent of the problem is much greater than presently recognized by the Government. This difference is partly because of confusion with regards to the UK definition of the phenomena. In the government review in the Sustainable Energy policy document (MED 2004) the indicator used is what people actually spend on household fuels (5% for the lowest economic groups as per p.49 in this report) rather than what they would need to spend, to attain a. healthy indoor environment (10% - 14% and rising to possibly as much as 32% in Dunedin in the lower South Island). That people actually use little fuel use for space heating in NZ is reinforced by various studies showing relatively low indoor temperatures (Lloyd et. al. 2004, BRANZ 2003) in NZ and the apparent energy efficiency of the residential sector compared to other OECD countries (Schipper et al IEA 2000). It can also be concluded that recent increases in energy prices, especially electricity prices since 2001, will certainly acerbate the situation and mean that a reassessment of the fuel poverty situation in NZ will need to be done within a few years.

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