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Household Energy Affordability: A Literature Review

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1.0 Executive Summary

This report is the first in a series of reports from the Household Energy Affordability project. The research objectives of the Household Energy Affordability project are to:

- develop an appropriate measurement of household energy affordability in the context of household energy use for New Zealand which provides a framework to understand the problem and explore solutions
- understand how people think about heating, household energy use and affordability, and how they make choices about expenditure on energy
- establish estimates of the extent of energy affordability problems in New Zealand and define which groups are most at risk
- support the development of policy and other responses to ensure improved household energy affordability
- establish ongoing interagency collaboration in the field of household energy affordability and energy efficiency.

The purpose of this report is to provide a summary of existing information related to household energy affordability. It will inform the development of a working measurement of household energy affordability, and will provide direction for qualitative research and the content of a survey.

Setting the research in a New Zealand context

New Zealand has a temperate climate, with significant variation between average temperatures in the north and south of the country. Minimum insulation standards were not included in building regulations until April 1 1978, and as a result many homes have insufficient or no insulation. Houses built since these changes are, on average, warmer and require less energy to heat than those built prior to 1978. High concentrations of pre-1978 homes are found in some of the coldest regions of New Zealand.

New Zealand households typically heat their homes between May and September. Many households either do not heat bedrooms, or heat bedrooms to a lower temperature than living areas during these months. Electricity is the most commonly used energy source for space heating, followed by wood and gas (both bottled and mains). However, the energy source used for space heating varies significantly between different regions of the country. For example, in many urban centres around New Zealand less than five percent of households use coal as their main heating fuel. In contrast more than 66 percent of households in Reefton use coal as their main source of heating.

Domestic energy prices have increased sharply both in New Zealand and internationally, and increases are expected to continue. Low income households are likely to be disproportionately impacted by increases in energy prices.

Defining energy hardship

Energy hardship has been commonly defined as the 'inability to heat one's home to an adequate temperature due to a low income and/or an energy inefficient home'. The predominant measure of energy hardship used in the United Kingdom (where it is referred to as 'fuel poverty') is 'the need to spend more than 10 percent of total

household income in order to ensure a healthy indoor environment'. While this measure is widely used, it has also been criticised by a number of authors.

Estimates of the prevalence of 'energy hardship' vary significantly between countries, due to both climate differences and the lack of a standard measure of energy hardship. Using an expenditure based measure, Lloyd (2008) found, based on his analysis, that 23 percent of households in the main centres of New Zealand may have experienced energy hardship, with a significant variation between southern New Zealand (Dunedin, 47 percent) and northern New Zealand (Auckland, 14 percent). These figures have increased significantly since Lloyd's 2006 predictions, which indicated that between 10 and 14 percent of households in the main centres of New Zealand could be living in energy hardship.

Factors related to household energy affordability

Household income is positively correlated with household energy expenditure. However, as income increases, energy costs make up a smaller proportion of total household expenditure. There is a significant variation in the proportions of household income spent on energy amongst low income households which indicates that some households spend little on energy in absolute terms.

Older homes tend to be colder; for each decade of age, a house is on average 0.15°C to 0.25°C cooler. New Zealand houses heated by open fires tend to be the coldest on average, while those heated by enclosed solid fuel burners tend to be the warmest.

When all else is held constant (building fabric, appliances, climate etc.), energy consumption often varies significantly due to household composition and behavioural differences.

Population groups with increased risk of energy hardship

The following groups are more likely to experience energy hardship:¹

- those living in older or less energy efficient homes
- tenants of private and social rental accommodation
- single person households and households with six or more occupants
- low income households
- older people
- sole parents
- rural households.

Health effects of living in cold, damp homes

Excess winter mortality refers to peaks in mortality rates which occur during winter, and which are largely attributed to changes in ambient air temperature. Excess winter mortality appears to be higher in countries with milder winters, such as New Zealand, than in countries with more extreme winters. This is thought to be due to less protective measures being taken in cold weather, such as space heating in homes,

¹ While prevalence of energy hardship is important for determining specific population groups at risk, it is also important to consider the absolute size of the energy hardship problem within sub-groups. For example, while there is a high rate of energy hardship amongst sole parents, there are far fewer sole parents than older people in energy hardship, due to the relative sizes of each of these population groups.

and wearing clothing appropriate to the weather. Ischaemic heart disease, cerebrovascular disease and respiratory disease account for approximately three quarters of excess winter mortality. Older people and those living in older homes appear to be more at risk of excess winter mortality. High temperatures have also been shown to increase mortality rates, indicating a 'U-shaped' relationship between ambient temperature and mortality rates.

Damp indoor spaces and mould are strongly associated with upper respiratory tract infections, coughing and wheezing, and asthma in previously sensitised individuals. Use of unflued gas heaters can have a significant negative impact on health.

Some interventions to date

Early interventions in the United Kingdom were based on direct winter payments to target groups in order to assist with energy bills. However, this approach has since been criticised as less effective than increasing the energy efficiency of homes and heating appliances.

In the UK energy providers are required to meet specific outcomes, including increasing energy affordability for low income households, and have been exceeding targets to date. In New Zealand and internationally policies have been put in place to ensure energy retailers work with low income households in an attempt to avoid disconnection.

Pre-payment meters are used by many households in energy hardship in the UK, with many incorrectly believing they are paying less for their energy than those using other payment methods. Smart metering and energy tariffs have been shown to result in more 'energy efficient' behaviour.

Improving the energy efficiency of homes via improving the thermal envelope and/or air-tightness of houses, and energy efficiency of appliances is widespread internationally, and has been shown to reduce heating energy required. However, evidence indicates that there is wide variation in the extent to which these measures increase comfort, or reduce energy expenditure and maintain pre-retrofit levels of comfort.

2.0 Introduction

Energy is essential for healthy living but is increasingly less affordable for New Zealand households. Cold houses are known to be associated with significant and expensive health and education costs. Household energy costs represent a substantial proportion of total household expenditure, and for many low income New Zealanders, particularly those in colder regions, paying household energy bills means going without other essentials, or adopting economising behaviours in order to reduce household energy expenditure. The negative effects of rising energy prices are further compounded by the poor thermal performance of the New Zealand housing stock.

The goal of the Household Energy Affordability (HEA) project is to explore the issue of energy affordability in New Zealand households. This project is partially funded by the Cross Departmental Research Pool, and is scheduled to be completed during 2011.

The research objectives of the Household Energy Affordability project are to:

- develop an appropriate measurement of household energy affordability in the context of household energy use for New Zealand which provides a framework to understand the problem and explore solutions
- understand how people think about heating, household energy use and affordability, and how they make choices about expenditure on energy
- establish estimates of the extent of energy affordability problems in New Zealand and define which groups are most at risk
- support the development of policy and other responses to ensure improved household energy affordability
- establish ongoing interagency collaboration in the field of household energy affordability and energy efficiency.

This is the first of a number of HEA reports that will respond to the issues above. Its purpose is to provide a summary of existing information related to household energy affordability to inform the research project going forward. It will contribute to the development of a working measurement of household energy affordability, provide direction for qualitative research investigating household energy affordability and guide selection of content for a survey.

Internationally, the problem of household energy affordability is referred to by a number of names, most commonly 'fuel poverty'. The term *household energy affordability* has been adopted for this project as it:

- directly articulates the focus of the project, namely energy affordability
- will not be confused with transport 'fuel' which is not in the project scope
- allows energy affordability to be considered for the New Zealand context without any unnecessary 'shaping' that may occur if overseas terminology were adopted, particularly in the early project stages.

For this project, household energy affordability is defined as 'the relative affordability of household access to energy services'². This definition acknowledges that:

- household energy affordability relates to the wellbeing of all households, not just to those in energy hardship

² While this definition relates to all energy services, much of this report focuses on space heating energy. This reflects the greater coverage of this topic in the literature.

- the term ‘relative’ conveys the idea that some households have more ability to afford energy services than others
- the focus on energy services reflects the reality that people are not interested in purchasing energy per se, rather they value the access they have to the services that energy provides.

Where reports are directly quoted, the terminology in those reports has been used. The term ‘fuel poverty’ appears frequently, reflecting the UK’s interest in this subject. For the HEA project, households that are unable to afford access to sufficient energy services are referred to as being ‘in energy hardship’.³

2.1 Structure of the report

Section 3.0: Methodology describes how material was selected for this report, and outlines the peer review process.

Section 4.0: Context provides background information relevant to a discussion of household energy affordability in New Zealand. The topics covered include the New Zealand climate, housing quality, heating practices, and trends in energy prices.

Household energy affordability has been defined and measured in a variety of ways. Section 5.0: Defining Household Energy Affordability describes common definitions and measures – focusing on expenditure based, and consensual measures – before briefly discussing international estimates of the prevalence of energy hardship.

Section 6.0: Contributing Factors describes how several factors relate to the issue of household energy affordability - income, energy costs, energy efficiency of home and appliances, and occupant behaviour.

Section 7.0: Vulnerable Populations summarises research exploring how rates of energy hardship vary between population groups.

Section 8.0: Health Outcomes summarises international research on excess winter events (mortality and morbidity), as well as discussing the health impacts of unflued gas heaters and damp/mould.

Section 9.0: Interventions outlines the main types of interventions used to address energy hardship to date. Where possible, information relating to the effectiveness of interventions is included.

³ For a more detailed discussion of the definitions of household energy affordability and energy hardship, see ‘Measuring Energy Affordability’ (MSD, 2009, pending publication).

3.0 Methodology

This review of the literature will provide a broad contextual understanding of household energy affordability issues both nationally and internationally. Due to the extensive availability of literature in this area, this review has focused on key issues identified from a broad, but not exhaustive, range of reports.

Selection of materials

The Ministry of Social Development Knowledge Services Unit carried out a search of the internet and the following databases:

- Knowledge Services database
- The National Bibliographical Database
- Index New Zealand
- Newztext
- Sociological Abstracts
- Austrom
- PsycINFO
- InfoTrac
- EBSCOhostEJS
- Australia/New Zealand Reference Centre
- EconLit
- MasterFILE Premier
- Business Source Premier
- SocINDEX
- Regional Business News
- International Bibliography of the Social Sciences
- Social Services Abstracts.

Search terms used included the following:

- fuel* or power or energy or electric* or gas* or heat*
AND
- hous* or afford* or poverty or poor or disadvantaged or entitle* or vulnerab* or solution* or effective* or success* or behave* or outcome* or legislat* or govern* or elderly* or discount* or policy or policies or regulation* or attitude* or income* or health or assist*.

The database and internet searches produced a large number of references which were reviewed and chosen on the basis of a relevant abstract, or where no abstract was available, the title of the work. Priority was given to works published since 1990.

Peer review

In order to ensure that all relevant issues were covered, a group of external peer reviewers were contracted to provide comment and recommendations on an early draft. These peer reviewers were selected as experts in the field of household energy affordability.

4.0 Context

This section outlines relevant context to the issue of household energy affordability in New Zealand, covering issues such as the New Zealand climate, housing stock and domestic heating practices, as well as local and international trends in energy prices.

SUMMARY

- New Zealand has a temperate climate, with significant variation between average temperatures in the north and south of the country.
- Minimum insulation standards were not included in building regulations until April 1 1978, and as a result many homes have insufficient or no insulation.
- Research indicates that houses built since these changes are on average, warmer and require less energy to heat than those built prior to 1978.
- High concentrations of pre-1978 homes are found in some of the coldest regions of New Zealand.
- New Zealand households typically heat their homes between May and September.
- Energy sources used for space heating vary significantly between different regions of the country. For example, in many centres around New Zealand less than five% of households use coal as their main heating fuel, while in Reefton around two thirds of households do.
- Electricity is the most commonly used energy source for space heating, followed by wood and gas (both bottled and mains).
- Research indicates that many households either do not heat bedrooms, or heat bedrooms to a lower temperature than living areas.
- Domestic energy prices have increased sharply, both in New Zealand and internationally, and are projected to continue to increase.
- Low income households are likely to be disproportionately impacted by increases in energy prices.

4.1 *New Zealand climate*

The National Institute of Water and Atmospheric Research New Zealand (2004, in Shen, 2004, p6) notes that mean annual temperatures range from approximately 10°C in the south to 16°C in the north of the country. This considerable difference in temperature between the north and south of the country is reflected in the heating degree days for different regions⁴. Invercargill has around 2,980 heating degree days, using a base of 18°C, compared with 1,150 in Auckland (Shen, 2004). This indicates there is likely to be wide variation in the energy required to sufficiently heat homes throughout different regions of the country.

This finding is supported by results from the Household Energy End-use Project (HEEP) which found that on average while heating made up around 25 percent of energy expenses in Wellington, it accounted for approximately 50 percent of energy expenses in Dunedin and Invercargill (Isaacs et al 2006).

⁴ 'Heating degree days' represent the number of days where average temperatures are below a set level, weighted by the deficit in °C. For example, using a base of 18°C, a day with an average temperature of 16°C would add two heating degree days to the annual figure.

Table 1 below illustrates the impact of different climates on household energy needs. The numbers in this table are indicative as they are based on modelled averages, and a range of assumptions such as house size/typology, heating and occupancy patterns (for more information about the model see Lloyd, 2006). However, Table 1 clearly demonstrates the greater need for energy in New Zealand's colder regions.

Table 1: Energy needed to maintain WHO indoor temperature guidelines in selected New Zealand cities

	Heating Energy Needed (kWh/y)	Other Electricity kWh/y	Total energy cost @ 9.5 c/kWh (2001 prices)
Auckland	4,000 – 6,000	5,500	\$900 - \$1,100
Wellington	8,000 – 13,000	5,900	\$1,300 - \$1,800
Christchurch	11,000 – 15,000	6,200	\$1,600 - \$2,000
Dunedin	13,000 – 16,000	6,600	\$1,850 - \$2,150

Source: Lloyd (2008, presentation at Community Energy Action conference in Christchurch, New Zealand)
 Notes: Differences in non-heating energy use reflect the greater energy required for water heating in colder climates

Climate is a major driver of indoor temperatures in New Zealand. Research (French, Camilleri, Isaacs and Pollard, 2006) suggests most houses are heated between 5.5 and 8.6 months each year, depending on location, with around three percent of houses not heated at all and four percent of houses heated constantly.

New Zealand can experience relatively large temperature swings over a 24-hour period that, when combined with typical house construction (eg low mass, large glazing areas), can put added pressure on households to moderate these temperature fluctuations through the use of energy (for example, see French, Camilleri and Isaacs, 2007).

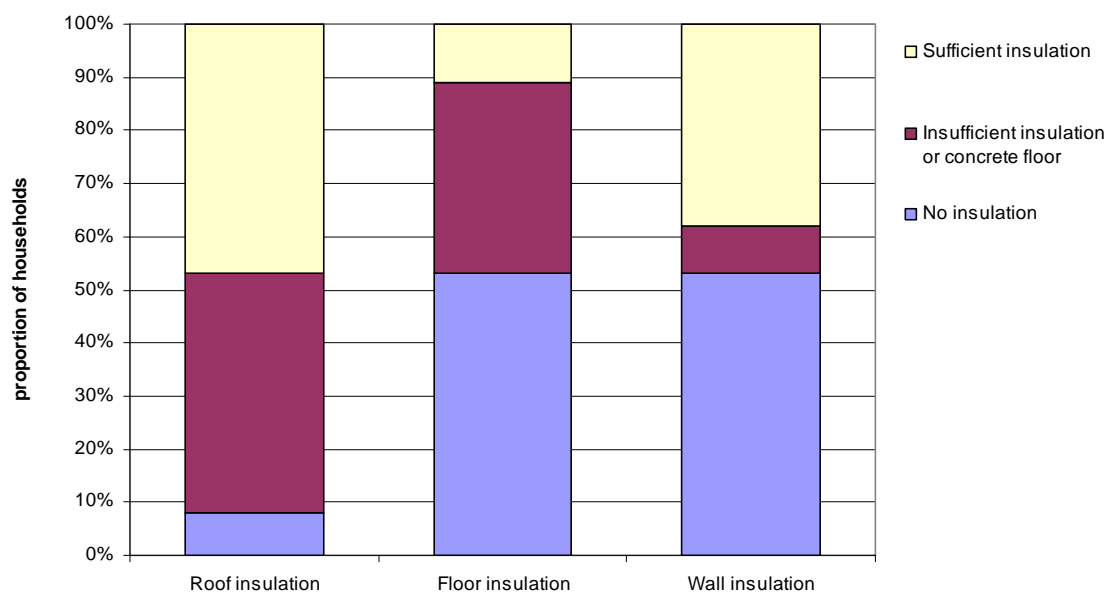
4.2 New Zealand housing stock

Prior to April 1 1978 there were no minimum insulation standards in New Zealand building regulations (EECA, 2000, in Shen, 2004, p2). Approximately two thirds of homes were built prior to these regulations and as a result “at least 0.5 million houses still have no, or only partial/sub-standard, ceiling insulation, with higher numbers lacking wall and floor insulation” (Ministry for the Environment, 2005a, p.10). Figure 1 and Table 2 (on the following page) from Griffin (2007), show that poor levels of insulation are present in many pre and post-1978 houses.

Research has identified significant differences in terms of temperature and energy use between homes built pre and post-1978. Isaacs (2004, p5) notes that houses built since the building regulation changes in 1978 are significantly warmer than those built prior, and that this difference is achieved without additional expenditure on energy. In a study of New Zealand homes, Camilleri, French and Isaacs (2008, p9) note that despite higher temperatures and larger average floor space (both of which would increase heating energy costs), total heating energy usage was (12-44 percent) lower in post-1978 homes than in those built prior to the regulatory changes.

Povey and Harris (2005, p9) note that 86 percent of homes in Dunedin - one of the coldest regions in New Zealand - were built before 1977.

Figure 1: Proportion of New Zealand households with roof, floor and wall insulation as at March 2006⁵



Source: Griffin (2007)

Table 2: Number of New Zealand households with roof, floor and wall insulation, by pre and post-1978, as at March 2006

	Roof insulation	Floor insulation	Wall insulation
Pre-1978 houses			
No insulation	120,000 (12%)	812,000 (82%)	720,000 (73%)
Insufficient insulation	511,000 (52%)	48,000 (5%)	131,000 (13%)
Sufficient insulation	359,000 (36%)	130,000 (13%)	139,000 (14%)
Post-1978 houses			
No insulation	10,000 (2%)	43,000 (7%)	130,000 (21%)
Insufficient insulation	218,000 (35%)	132,000 (21%)	10,000 (2%)
Sufficient insulation	388,000 (63%)	441,000 (72%)	476,000 (77%)

Source: Griffin (2007)

Ryan, Burgess and Easton (2008) investigated how the design features of New Zealand houses have contributed to general energy performance and ease/cost of improvement. The authors note that some house types are relatively easy and cheap to improve (eg old villas, inter-war bungalows, state houses and mass housing from the 1930s to 1970s) and others are difficult and expensive to improve (eg 1960s and early 1970s multi-unit houses, art deco).

While significant progress has been made, there are pockets of poor quality rural housing in New Zealand. Between 2001 and 2006, Housing New Zealand Corporation carried out approximately 1,800 housing interventions⁶ in owner occupied housing in rural Northland, East Coast and Eastern Bay of Plenty (Jenkin,

⁵ The 'concrete floor' category is included with 'insufficient insulation' as it provides more insulation than an uninsulated cavity floor, yet is not 'sufficient'.

⁶ The majority of these interventions included one or more of insulation, ventilation and replacement of heating source.

2008, p4.16). Jenkin notes that this is estimated to have addressed only 20 percent of the poor quality housing in these regions.

Jenkin (2008, p5.4) carried out an environmental scan of current (as at 2007) social and affordable housing stock in New Zealand, for the Housing New Zealand Corporation Future Scenarios workstream, and noted that increasing energy costs could result in increased demand for social housing.

There are few quality requirements for existing New Zealand houses. The Residential Tenancies Act (Department of Building and Housing, 1986) requires landlords to keep their premises in a reasonable state of repair, but this does not require them to undertake any energy improvements. The Housing Improvement Regulations 1947 (Ministry of Works, 1947) sets a number of general quality requirements for houses (eg ventilation, overcrowding, minimum room sizes), and states that an approved form of heating shall be fitted in every living room. However, these regulations are out of date (Department of Building and Housing, 2004, p20).

In contrast, for example, the UK Government has implemented a Decent Homes Standard to raise housing quality. A decent home is defined as one which is *wind and weather tight, warm and has modern facilities*. The repair, maintenance and improvement requirements are based around four key components that include a *reasonable degree of thermal comfort*, and significant funding has been made available for improvements, such as heating (Department for Communities and Local Government, 2005).

The UK Government has set a target for all social housing to meet the target by 2010, and has implemented support mechanisms to encourage councils and registered social landlords to meet this target. There has been continued improvement towards the standard across the English housing stock as a whole and within each housing sector, with steady improvement between 1996 and 2006 (Department for Communities and Local Government, 2008, p16). The rate of improvement has been faster since 1996 for the households targeted by decent homes and related programmes, namely social tenants and poorer households in the private housing sector.

4.3 New Zealand population

Statistics New Zealand (2007a) population projections⁷ indicate that, based on 2006 Census data:

- The number of households is projected to increase to 2.09 million in 2031 from 1.55 million in 2006.
- Over this period the number of one person households is projected to increase by 71 percent from 363,000 to 619,000.
- The average size of families will decrease from 2.6 to 2.4.

This significant increase in one person households is partially due to the ageing New Zealand population. Statistics New Zealand (2007a) note that under all population projection scenarios “the number of New Zealanders aged 65 years and over is projected to exceed one million by the late 2020s, compared with half a million in 2006”.

⁷ Population projections based on series 5B which assumes “medium fertility, medium mortality, long term net migration of 10,000 and ‘B’ living arrangement type rates”, with living arrangement type projected by age and sex.

Statistics New Zealand (2008a, p5) also notes that, based on 2006 Census data, there is likely to be an increase in the number of sole parent families:

“The number of one-parent families is projected to increase by 63,000 (29 percent), from 219,000 in 2006 to 282,000 in 2031. This increase is because of population growth, changes in population age structure and an assumed higher rate of single parenting. The latter is due to increasing numbers of separations and divorces, increasing rates of childbearing outside of couple relationships and more complex shared care arrangements with parents residing in different households... The number of two-parent families is projected to decrease after 2006, because of the continuing trends towards single parenting and fewer couples having children. Under series 5B, the number of two-parent families is projected to decrease from 481,000 in 2006 to 425,000 by 2031.”

The changing nature of households in New Zealand could have implications for rates of energy hardship in the future. Refer to Section 7: Vulnerable Populations, for further projections.

4.4 Heating practices in New Zealand

4.4.1 Internal temperatures

Schipper et al (2001, in Shen, 2004, p2) note that “by 1995 New Zealand had the lowest space heating intensity (measured as energy per square metre per day) of all the countries studied”. This is supported by research that has consistently shown that the temperatures in many New Zealand homes are often very low (for example, Shen, 2004; Lloyd, 2006; Isaacs, et al, 2006). This indicates significant levels of under heating in New Zealand homes.

The average New Zealand household heats its house between May and September (Isaacs, 2004, p4). A survey of Rotorua heating energy use supported this finding, and added that there was also a shoulder period - the months of April and October - during which approximately 30 to 40 percent of homes in that region are heated (Iremonger & Graham, 2006, p7).

The Household End-use Energy Project (HEEP) found houses heated by enclosed solid fuel burners the warmest, and houses heated by LPG or electricity the coolest. Note that HEEP data largely predates the considerable increase in heat pumps that has occurred in recent years, and internal temperatures associated with electric heating may have moved in that time.

Research indicates that living areas of homes are often heated to a higher temperature than bedrooms. Shen (2004, p97) found that in a sample of Dunedin and Southland homes, during July 2003 the average living room temperature was 12.7-13.3°C, compared with the average bedroom temperature of only 9.9-10.3°C.⁸

⁸ The UK Government recommends a minimum temperature of 21°C for living areas and 18°C for the rest of the house (see Section 5.1).

4.4.2 Heating sources

HEEP explored how end-use energy was used in a sample of New Zealand homes between 1995 and 2005, and found that (Isaacs et al 2006):

“... on average, across all fuel types, space heating is the largest single end-use (34%), followed by hot water (29%), appliances (13%), refrigeration (10%), lighting (8%) and cooking (6%). The most important fuel source is electricity, while the most important space heating fuel is solid fuel (wood and coal)... Electricity provides three quarters (75%) of energy used for hot water, with gas (20%) and wetback (5%) providing almost all of the rest.”

As noted above, the HEEP data predates the recent proliferation of heat pump installations, and it is possible electricity has increased its share of overall heating energy use in recent years.

The Ministry for the Environment (2005a) carried out a series of telephone surveys exploring domestic heating energy use, the results of which are included in Table 3 (following page). The rows in the table are organised from south to north.

Table 3 clearly indicates significant variation in energy source for heating throughout the country. Electricity used for space heating ranges from 20 percent to 77 percent of households, gas from 13 percent to 64 percent, wood from 20 percent to 96 percent, and coal from one percent to 67 percent. It is important to note that these figures report the proportion of households that are using each energy source, not the quantity of the fuel used (as different heating methods will require more or less fuel).

Table 4 (following page) summarises the use of various fuel types for space heating 1996-2006, based on Census data.

The Census estimates of heating energy vary slightly from those presented in Table 3. The Census asked respondents to indicate all fuel types used for space heating, and the MfE survey asked respondents to identify the ‘main’ fuel type used for space heating.

The National Environmental Standards for Air Quality (NESAQ) were implemented in 2004 to help address poor air quality in New Zealand (Ministry for the Environment, 2004). The NESAQ have resulted in a number of actions around solid fuel burners which may constrain their use in future years. For example, Environment Canterbury’s Clean Heat project means that from April 1 2010 “open fires and solid fuel burners 15 years or older cannot be used in Christchurch during winter” (Environment Canterbury, 2009). This is likely to have implications for households who use solid fuel for space and/or water heating, particularly households who access free or low cost firewood.

Table 3: Proportion of households using selected energy sources for space heating in their 'main living area', by region⁹

	Electricity	Flued Gas	Unflued Gas	Oil	Wood	Coal
New Zealand	57	9	24	2	52	7
Invercargill	63	5	13	3	58	39
Balclutha	53	3	11	1	74	47
Milton	43	5	18	2	77	35
Gore	50	5	11	7	72	47
Mosgiel	59	6	10	4	65	19
Dunedin	77	7	13	2	30	12
Alexandra	59	4	9	5	67	9
Oamaru	47	6	12	1	79	13
Cromwell	47	3	10	3	84	19
Arrowtown	51	14	13	3	83	21
Timaru	59	10	15	2	61	11
Ashburton	61	9	12	4	63	8
Christchurch	72	8	17	1	25	2
Richmond	48	4	18	1	61	1
Kaiapoi	48	7	16	1	59	4
Rangiora	51	8	12	1	65	3
Reefton	24	1	13	1	96	67
Westport	35	5	21	1	79	52
Blenheim	61	0	14	0	63	4
Nelson	44	8	25	2	59	4
Wainuiomata	41	35	24	0	41	2
Upper Hutt	34	36	15	1	37	1
Masterton	20	6	26	0	86	5
Napier	42	20	33	0	51	1
Gisborne	35	17	27	1	51	1
Te Kuiti	39	8	21	1	67	5
Rotorua	35	24	20	1	46	1
Hamilton	26	36	28	0	20	3
Auckland	48	12	23	2	28	5

Source: Figures are taken from tables throughout the Ministry for the Environment (2005) report, Warm Homes Technical Report: Home Heating Methods and Fuels in New Zealand

Table 4: Percentage of fuel types used to heat dwellings (total responses) for private occupied dwellings (1996, 2001, 2006 Census)

Fuel type	1996	2001	2006
Electricity	77.2	72.0	74.8
Mains gas	11.6	13.5	13.2
Bottled gas	22.3	28.3	27.7
Wood	48.7	44.7	40.9
Coal	13.0	9.3	7.0
Solar Power	0.7	0.9	1.1
No fuels used in this dwelling	0.9	2.8	2.4
Other fuel(s)	1.9	1.1	2.1

Source: Statistics New Zealand (2007b)

⁹ The total New Zealand figures are based on a sample of 201 households and have a sample error of 6.9%. The site specific figures are based on samples of approximately 150 households and have a sample error of approximately 7.8%.

Heat pumps account for an increasing share of heating energy in New Zealand. National sales increased more than 300% between 2001 and 2006 (Buckett, 2007), with over 110,000 sold in the 2008 financial year (Winter, 2009).

Heat pumps could help to ameliorate energy hardship as they are a very efficient heating source when installed and used properly. However, Buckett (2007) notes that in New Zealand there is a tendency towards greater comfort levels rather than energy savings. Heat pumps are also being used by some households for cooling during warmer periods (Page, 2008), which could put added pressure on household resources.

4.5 Energy price trends

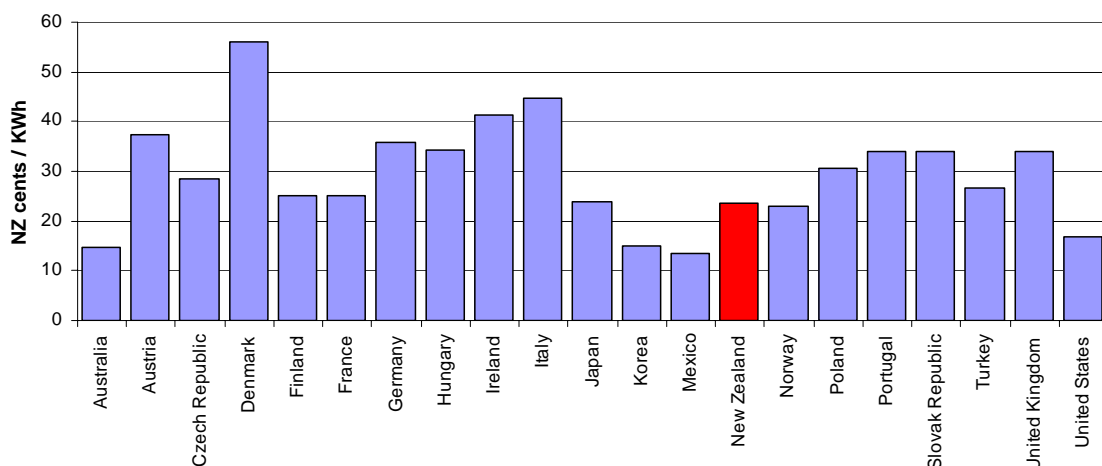
International research indicates that energy prices have been rising in recent years. Mulvy (2008, p2) reports that in the US “energy prices to consumers have increased 70% between 2000 and 2007 ... More recently, in 2007, overall energy prices rose 17.4% ...”. There have been similar increases in the UK, with the UK Government reporting that (Department for Business, Enterprise and Regulatory Reform (BERR) & Department for Environment, Food and Rural Affairs (DEFRA), 2008a, p16):

“the overall cost of energy to domestic consumers rose by 22% in real terms between 2005 and 2006, with gas prices rising by 29% and electricity prices rising by 19%. ... prices rose in early 2008 by an average of around 15% for gas, and 13% for electricity. Subsequently, they rose again during the summer of 2008, by an average of around 30% for gas and 14% for electricity.”

The House of Commons: Business Enterprise Committee (2008, p48) notes that due to wholesale gas price increases during 2008, both gas and electricity costs for domestic consumers in the UK are predicted to rise significantly, “with serious consequences for millions of households, and especially the fuel poor”.

Figure 2 below (based on data from Ministry of Economic Development, 2009) shows an international comparison of residential electricity prices. This indicates that New Zealand is lower to mid-table in price, but includes no consideration of income.

Figure 2: International comparison of energy prices, for September 2008 quarter (NZ Cents/kWh)



Source: Energy Data File, Ministry of Economic Development (2009)

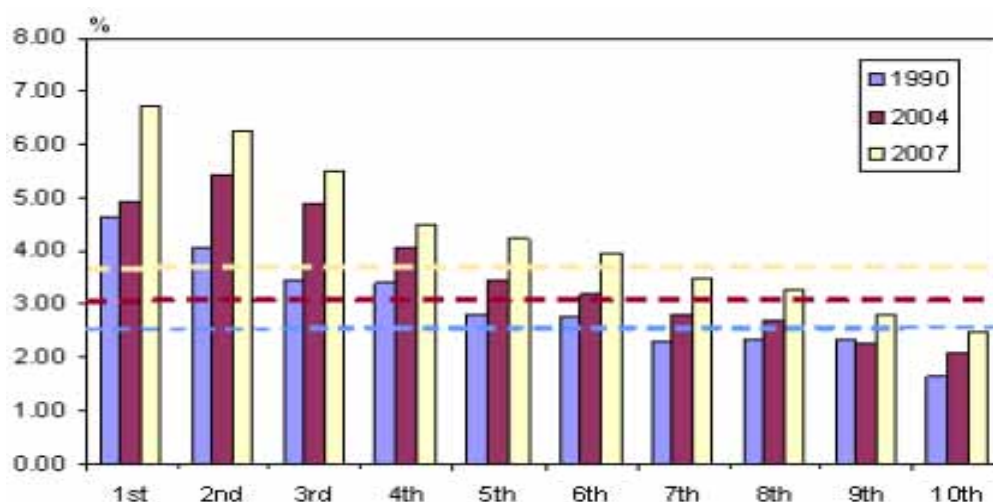
New Zealand residential energy prices increased 28 percent in real terms between 1999 and 2006 (Ministry of Economic Development, 2007 in Electricity Commission, 2008, p72). The Ministry of Economic Development (2006, p29) has projected residential electricity prices in New Zealand to increase by 20 percent between 2005 and 2030.

While an increase in energy prices will likely impact all consumers, Waddams-Price (2005, p129) notes that low income groups are likely to be impacted to a greater degree:

“low income groups spend a higher proportion of their income on energy, so that even if all fuel prices change in a similar pattern, the impact on different households varies; an increase or decrease in prices has a proportionately greater effect on low income than higher income groups.”

This is demonstrated in Figure 3 below (Ministry of Economic Development, 2008a) which shows the change in the cost of energy (as a percentage of total household income) across different income deciles. The dotted lines indicate the average percentage spent across all incomes for each year. Figure 3 shows that on average energy costs are a larger percentage of total household income in low income households than high income households. Between 1990 and 2007 the percentage of total household income spent on energy has increased, particularly for lower income households.

Figure 3: Average proportion of household income spent on household energy, by income decile



Source: Ministry of Economic Development (2008a)

Energy prices are likely to increase further in response to carbon pricing schemes (Dresner & Ekins, 2006, p46; Stanley, 2007, p60). Australian research (NIER, 2007, in Stanley, 2007) indicates that, assuming a ‘conservative’ value of \$A25 per tonne of carbon dioxide, energy bills for a typical high income Australian household will increase by around \$1,530 per year (0.4 percent of household expenditure), compared with \$670 per year (2.5 percent of household expenditure) for a low income Australian household.

In addition to increasing energy prices, Stanley (2007, p61-62) notes that:

“a carbon price will raise the cost of all consumer goods, disproportionately impacting on lower income households, who spend a higher proportion of their income on essential items (such as food and heating) than higher income households. The higher income household also has greater capacity to move to alternative goods which, although is likely to have a higher initial cost, may have longer term cost savings.”

5.0 Defining Energy Hardship

This section will discuss some of the ways in which energy hardship has been defined and measured.

As noted earlier, household energy affordability is defined for this report as the relative affordability of household access to energy services. The term 'energy hardship' is used throughout this report to describe the inability to afford access to sufficient energy services. There are numerous terms used internationally to describe this issue, such as fuel poverty, energy poverty and affordable warmth. For clarity, this section will use the term energy hardship in place of these other terms, except for direct quotes.

SUMMARY

- Typically energy hardship is defined as the 'inability to heat one's home to an adequate temperature due to low income and/or an energy inefficient home'.
- The predominant measure of energy hardship used in the UK is 'the need to spend more than 10 percent of total household income in order to ensure a healthy indoor environment (an 'expenditure based measure')'.
- 'Consensual measures' are becoming increasingly common, and are based on social indicators / lack of energy services thought to be related to energy hardship.
- Prevalence estimates vary significantly between countries, due to both climate differences and the lack of a standard measure of energy hardship.
- Using an expenditure based measure, Lloyd (2008) found based on his analysis that 23 percent of households in the main centres of New Zealand could be living in energy hardship, with significant variation between southern New Zealand (Dunedin, 47 percent) and northern New Zealand (Auckland, 14 percent).

5.1 Historical definitions

Lewis (1982, in Sustainable Energy Ireland, 2003, p10) defined energy hardship as "the inability to afford adequate warmth in the home". Sustainable Energy Ireland (2003) tracks the evolution of the definition of energy hardship through Boardman's (1991) definition: "the inability to afford adequate heat because of energy inefficiency in the home" to Clinch and Healy's (2001) "the inability to heat ones home to an adequate (safe and comfortable) temperature owing to low income and poor (energy inefficient) housing".

These definitions are conceptual, in that without further assumptions they are unable to be applied to measure the prevalence or severity of energy hardship. Further clarification and quantification is needed around terms such as adequate energy services, warmth and heat.

Boardman, (2000, in Morrison & Shortt, 2008) noted the need for greater clarity around the concept of 'adequate energy/heat'. The UK Government defines 'adequate' or 'safe and comfortable' heat as a temperature of 21°C for the main living area and 18°C for the rest of the house (Healy & Clinch, 2002, in Burholt & Windle,

2006, p1198; Wright, 2004, p491). Sustainable Energy Ireland (2003, p11) report that the majority of medical literature recommends “a minimum temperature of 16°C for able-bodied, healthy people but recommends a minimum of 18°C for sedentary activities and 21°C for the more vulnerable”. DEFRA (in Lloyd, 2006, p143) state that the entire house is to be heated to these temperatures, unless the house is ‘under-occupied’ in which case only half of the house needs to be heated.

5.2 Definitions and measurement

Recent literature almost universally defines energy hardship in terms of a measure. Very few definitions are conceptual (as those above), and are instead focused on estimating the number of households in energy hardship.

There are several methods of measuring energy hardship, ranging from “absolute indicators which assess the level of fuel poverty suffered by individual households” to “local area indicators... which measure the relative risk of fuel poor households living in an area” (Pither & Moore, 2006, in Morrison & Shortt, 2008, p705). Morrison and Shortt go on to note that the relative costs of these measures varies from the “expensive, yet absolute, process of performing an individual house assessment, to the comparatively inexpensive yet less accurate method of combining social variables from the census to determine which areas are relatively more likely to include fuel poor households”. These two approaches are examples of expenditure and consensual measures of energy hardship respectively. The remainder of this section will summarise these two approaches.

5.3 Expenditure based methods

As noted above, the predominant measure of energy hardship in the UK is based on a ratio of household income to household energy costs; an expenditure based definition. Boardman (1991, in Morrison Shortt, 2008, p702) defined energy hardship as the “inability to obtain adequate energy services for 10% of household income”. This threshold definition of household energy affordability has been used widely by community and government groups (BERR and DEFRA, 2008a; House of Commons: Business and Enterprise Committee, 2008; National Audit Office, 2003), and by academic literature internationally (Illsley, Jackson & Lynch, 2007; Waddams-Price, 2005; Burholt & Windle, 2006; etc.) and in New Zealand (Lloyd, 2006). This threshold based measure is useful as it provides a clear distinction between households that are in energy hardship and those that aren't.

While this method has been widely used, it has also been criticised by a number of authors. A significant criticism of this definition is that “there does not appear to be any substantial rationale behind setting the budget line at 10% of net income, and therefore this approach has been seen by some as lacking in any scientific basis” (Healy & Clinch, 2004, p203; Sustainable Energy Ireland, 2003, p11).

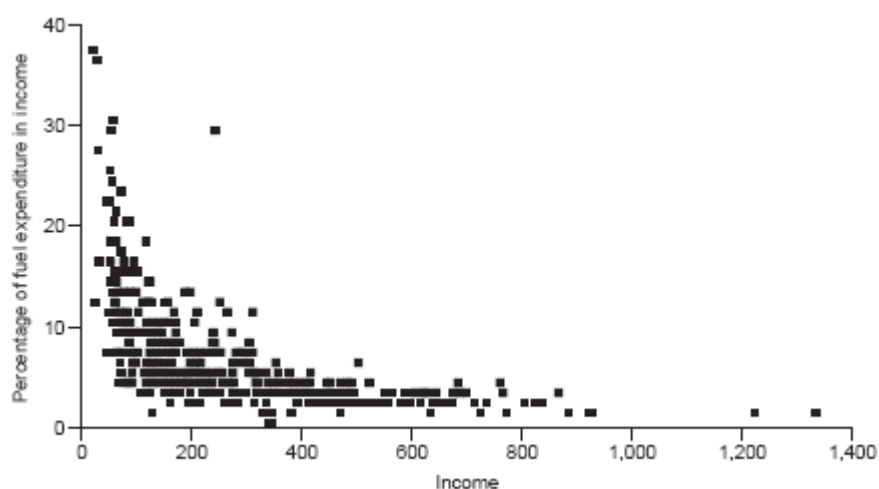
Some authors note that most expenditure based definitions of energy hardship are simply functions of income and energy expenditure, which “fails to fully take into account the complex relationship between household characteristics, income, energy efficiency, energy related knowledge, access to fuel and fuel price” (Shortt & Rugkasa, 2007, p99) or the importance of factors such as energy infrastructures (Buzar, 2007, p1912).

Another criticism of this definition of energy hardship is that no standard formula exists, for example some definitions use gross income as opposed to net, while

others use income minus housing costs (Healy & Clinch, 2004, p208). An example of this is that the UK, Ireland, Scotland and Wales all use slightly different definitions (BERR & DEFRA, 2008a, p6; Wright, 2004, p491), resulting in difficulty comparing national estimates for these countries.

A further problem with this approach is that some low income households are unable to afford sufficient energy and, as a result, their energy expenditure does not accurately reflect their actual *need* for energy (Sustainable Energy Ireland, 2003, p11; Bennett, Cooke & Waddams-Price, 2002, p171). Figure 4 below plots household income against proportion of total income spent on energy costs, as presented in Bennett, et al (2002).

Figure 4: Relationship between energy expenditure as a proportion of income and household disposable income (£ per week)



Source: Bennett, et al (2002)

Figure 4 shows the distribution of household spending on energy as a proportion of total household income. At the higher end of the income spectrum, households appear to spend much lower proportions of household income on energy costs, in contrast with lower income households. Lower income households appear to vary significantly in the proportion of total household income spent on energy costs, indicating that some low income households are spending very little on energy in absolute terms. Relying on actual energy expenditure, without taking into account the sufficiency of energy use within a household, could lead to many households being incorrectly labelled as 'not in energy hardship'.

The following section discusses this problem, in terms of the contrast between actual expenditure on energy and the required expenditure on energy in order to maintain a healthy indoor environment.

5.3.1 Actual vs required expenditure on energy

Some research has acknowledged that low income families economising on energy expenses can result in households being incorrectly labelled as 'not in energy hardship', when the economising behaviour is actually a symptom of energy hardship.

Waddams-Price (2005, p.129) notes that:

“although fuel poverty is defined in terms of the need to spend more than 10% of household income on energy, authoritative figures on heating *need* are hard to link with other household characteristics, so we confine our analysis to households that *do* spend more than a tenth of their income on fuel. Such households are a subset of the fuel poor group that can be classified as ‘expenditure fuel poor’ (EFP).”

Households in energy hardship based on expenditure data that Waddams-Price is referring to can be seen in the upper left-hand section of Figure 4 above. While households not counted by this definition are likely to be in the cluster in the lower left-hand section. The concept of ‘expenditure fuel poor’ was also used by Bennett, et al (2002, p173), who noted that data on required energy is not readily available. While the ‘10 percent threshold’ measure is common, it is also difficult to put into practice due to the complicated data required.

One solution to this lack of available data is to model household energy use and use the results as estimates for the required energy. The following is a summary of how the UK Government models required energy by using a series of household factors (summarised from BERR & DEFRA, 2008a, pp40-41):

- Energy costs are calculated as energy price x energy usage.
- Energy price is calculated using existing data, and is calculated at the regional level by energy type.
- Energy usage is “modelled based on a number of factors, including”:
 - the size of the property
 - the “energy mix usage” within the house; how energy use is split between energy services such as space heating, water heating and lighting
 - the heating regime (during evenings and weekends only, constantly, or partial house heating for under-occupied dwellings)
 - the energy efficiency of the home.

This process obviously requires gathering a large amount of data in order to generate estimates of required household energy expenditure.

5.4 Consensual methods

One alternative to using household income and actual/required energy expenditure data to determine whether a household is in energy hardship is referred to in the literature as the ‘consensual’ method. Sustainable Energy Ireland (2003, pp11-12) notes that this approach is based on the work of poverty and deprivation researcher Peter Townsend and that the basic principle of the approach is that:

“certain goods and services are considered to be necessary, not just by academics and ‘experts’, but by society at large. Some of these necessities fall under the umbrella of fuel poverty: the absence of certain items regarded as essential household attributes may be considered indications of fuel poverty.”

Fahmy and Gordon, (2007, in Morrison & Shortt, 2008, p705) provide an example of a consensual measure of energy hardship being used in the UK, the Centre for

Sustainable Energy Fuel Poverty Indicator (FPI), which uses Census data matched to postcode level housing data. The following Census variables were used in calculating risk of living in energy hardship (Baker, Starling & Gordon, 2003, in Morrison & Shortt, 2008, p705):

- unemployed households
- under-occupied households
- households with no access to a car
- households with no central heating
- single pensioner households
- lone parent households
- private renting households
- households including a disabled person

These variables are considered indicators that a household may be living in energy hardship, with multiple positive responses indicating increased likelihood. Most of these variables were based on specific groups which previous research has shown to have a higher risk of energy hardship (see Section 7.0), while lack of access to a car was used as a proxy measure for low income due to the lack of a household income question in the Census (Morrison & Shortt, 2008, p705).

Rudge and Gilchrist (2005, p354) used a small area Fuel Poverty Risk index (FPR) to explore the association between energy hardship and increased incidence of respiratory episodes amongst older people during winter. The FPR used the following variables:

- Low income: receipt of Council Tax Benefit was used as an indicator of low income.
- Poor housing: homes with an energy efficiency rating below the 1991 UK average.
- Age: households including pensioners.
- Under-occupation: one or two-person households occupying homes with five or more bedrooms.

Sustainable Energy Ireland (2003, pp.19-21) provide another example of variables used in a consensual measurement of energy hardship:

- unable to adequately heat home
- unable to pay scheduled utility bills
- inadequate heating facilities
- presence of damp
- presence of rot in windows
- lack of central heating.

Data for these variables is collected via survey and weighted before being used to indicate the risk of homes having difficulty affording their energy bills. Based on analysis of the data and consultation with experts, the item 'unable to adequately heat homes' was given a weight of 0.5 while the remainder were given weights of 0.1.¹⁰ Prevalence for each of these factors, for the period 1994–1997, is shown in Table 5 (following page).

¹⁰ Sensitivity analysis was carried out in order to explore the impact of different weighting on findings. No significant difference was found between different weightings, except for a weighting which only used the first three items and gave them all equal weight, which was found to produce lower estimates of the incidence of fuel poverty.

Table 5: Proportion of households identifying variables used as indicators of fuel poverty in Ireland

Variable	1994	1995	1996	1997
Unable to adequately heat home	8.0	5.9	6.5	5.1
Unable to pay scheduled utility bills	8.4	6.3	6.1	4.9
Inadequate heating facilities	9.6	7.4	7.6	7.0
Presence of damp	10.5	9.4	8.9	9.4
Presence of rot in windows	8.9	6.4	7.0	6.7
No central heating	23.8	20.8	19.8	16.4

Source: Adapted from Sustainable Energy Ireland, 2003

These consensual based measures (particularly those of the Fuel Poverty Index, see pp23-24) have some similarities to the New Zealand Deprivation Index 2001 (NZDep2001). NZDep2001 is a measure of socio-economic status for small geographic areas, based on New Zealand Census data. Salmond and Crampton (2007, p6) note that for any given area unit, the index is constructed using the proportion of people:

- aged 18-59 years receiving a means tested benefit
- aged 18-59 years who are unemployed
- living in equivalised¹¹ households with income below a threshold
- with no access to a telephone
- with no access to a car
- aged less than 60 years living in a single parent family
- aged 18-59 years without any qualifications
- not living in their own home
- living in equivalised households below a bedroom occupancy threshold.

These variables are used to calculate the relative deprivation of area units within New Zealand, which are allocated to one of 10 deciles, 1 being the least deprived areas and 10 the most deprived areas.

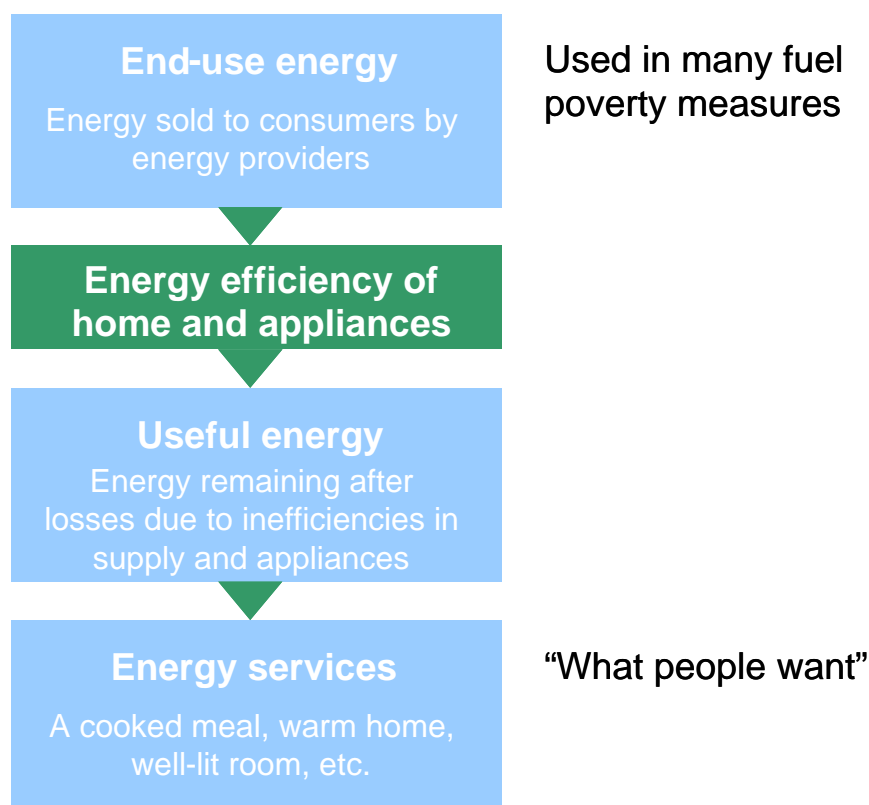
5.4.1 Access to energy services

Pachauri and Spreng (2003, p2) state that while traditional definitions often refer to energy services, the measurements used to assess prevalence simply look at energy supply. For example, while some definitions often refer to the inability to heat a home adequately (an energy service), the measures often use raw energy cost data (end-use energy). Pachauri and Spreng (2003) describe an energy hierarchy which is summarised in Figure 5 on the following page. Pachauri and Spreng (2003, pp2-3) note that:

“what householders are looking for is not so much fuel or electricity, but rather heat supplied to a room or to a cooking pot or the mechanical energy applied to air for air circulation or to water to be lifted to a tank. They do not only have to acquire end-use energy, but also equipment such as heaters, stoves, pumps and lamps... The problem for the analyst is that these so-called energy services cannot be measured in energy units.”

¹¹ Equivalisation controls for household composition.

Figure 5: Household energy hierarchy



Source: Adapted from Pachauri and Spreng (2004, p3)

5.5 Local area vs household

Morrison and Shortt (2008) carried out an experiment comparing results from a Census area level measurement with a measurement based on individual household characteristics. Of 9,205 households, 1,871 were deemed to be in the top two deciles most at risk of energy hardship using a Census area unit measurement. Of these ‘at risk’ households, only 312 were deemed to be in the top two deciles most at risk of energy hardship when the measurement was made using data at the individual household level (p711). This could indicate that there is more variation between individual households within geographical area units than between these area units themselves. Morrison and Shortt conclude (2008, p713):

“the results presented here emphasise the dangers of ecological fallacy in the use of local area predictors of fuel poverty (including our own indicator at the output area level), and the generation of fuel poverty risk indices for relatively large spatial units demonstrated to mask smaller areas at risk of fuel poverty.”

5.6 Energy hardship as a binary indicator

From the literature reviewed for this report, the majority of methods for measuring energy hardship tend to be binary indicators. In other words, households are either living in energy hardship or they are not. This section discusses the implications of

this approach and contrasts these binary measures with other forms of measurement.

Sefton (2002, p376) notes that “even if people agree over the level of the ‘poverty line’, they may still be concerned about those who are above, but close to, the poverty line (ie those who are nearly fuel poor)”. A binary measure of hardship could also hide the presence or extent of changes in the distribution of households along the household energy affordability continuum. For example, a small increase in prevalence of energy hardship using a threshold based binary measure may hide a large shift in the distribution, pushing many households closer to the threshold.

Sefton (2002, p380) notes that a measure of the *difference* between required energy expenditure and what a household can afford is a more useful measure than assigning an arbitrary threshold, as it can take into account changes in the depth or severity of energy hardship. Sefton goes on to note that it can be used to target those in most need, and can be used to track improvements in the situation of households even if they remain below the threshold.

Healy and Clinch (2004, p209) report on findings from a national survey of Ireland, in which they included a four-point scale where respondents could indicate how often they were unable to adequately heat their home. The data from this item was used to construct estimates of persistent and intermittent fuel poverty, as opposed to a binary indicator. They note that the aggregate level of fuel poverty (intermittent and persistent) was higher than previous estimates of fuel poverty in Ireland based on data from surveys which used a binary response (yes/no). Healy and Clinch believe this is due to a large proportion of intermittently fuel-poor households not identifying as being in fuel poverty when binary measures are used. This indicates many binary measures of fuel poverty may only be capturing persistent as opposed to intermittent fuel poverty.

This indicates that binary indicators, often using average income values, may be missing those households who intermittently experience energy hardship due to shifts in income and/or energy costs. This could occur as respondents in intermittent energy hardship may not be in energy hardship at the time of the survey, or may be aware of the intermittent nature of their situation and feel a yes/no response is not appropriate.

By categorising households as ‘in energy hardship’ or ‘not’, binary indicators almost seem to be setting a standard or target. However, as noted above, the levels at which these thresholds are set appear to be arbitrary, and as such the threshold may be more useful as a trigger for action instead of a level that remedial work should be completed to.

5.7 Prevalence measures to date

Based upon material reviewed for this report, the UK has seen the most research carried out into the prevalence of fuel poverty. This is likely to be, at least in part, due to the UK Government’s commitment to eradicate fuel poverty for vulnerable households by 2010 (Department for Business Enterprise and Regulatory Reform, 2001, p1)

The level of fuel poverty varies greatly across the UK. Approximately 33 percent of homes in Northern Ireland are estimated to be living in fuel poverty (NEA, 2004a, in Shortt & Rugkasa, 2007, p99), compared with nine percent of households in

England, 13 percent of households in Scotland, and 31 percent in Wales (CSE/NRFC, 2001, in Shortt & Rugkasa, 2007, pp99-100).

Between 1996 and 2006, estimates for the number of fuel poor households in the UK fell from 6.5 million to 3.5 million (Department for Business, Enterprise and Regulatory Reform, Department for Environment, Food and Rural Affairs, 2008b, p.6). However, BERR and DEFRA estimate that fuel poverty numbers for 2005 were as low as 2.5 million, indicating an increase of approximately one million households over one year, attributed to increasing energy prices in the UK.

This trend is expected to continue, with Department for Business, Enterprise and Regulatory Reform, Department for Environment, Food and Rural Affairs (2008a, pp56-57) projecting that the number of fuel poor households in England will rise by around 1.2 million by March 2009. Similar trends have been seen in Ireland, Scotland, and Wales (pp7-8).

Sustainable Energy Ireland (2003, p27) report that 12.7 percent of Irish households experience intermittent fuel poverty, and another 4.7 percent persistent fuel poverty, compared with the estimate of nine percent from a binary expenditure based measure (the ECHP). The hypothesised reason for this difference is that many households with intermittent energy hardship problems are not reporting difficulties paying energy bills as it is seen as a temporary problem.

Prevalence estimates of energy hardship vary significantly between countries. The general trend is for countries with milder winters to have a higher winter mortality rate than those with the coldest winters (see Section 8.1 below). This section outlines the most recent estimates of the prevalence of energy affordability hardship.

Lloyd (2006) carried out computer modelling in order to produce estimates of energy hardship, and to indicate how energy hardship may vary by region in New Zealand.¹² Table 6 below summarises Lloyd's estimates for the main centres of New Zealand as at 2001.

Table 6: Estimates of the potential prevalence of energy hardship¹³ in the main centres of New Zealand as at 2001

Centre	Prevalence	Number of households
Auckland	6 – 8%	21,000-28,000
Wellington	9 – 14%	11,000-17,000
Christchurch	18 – 25%	22,000-33,000
Dunedin	26 – 32%	11,000-14,000
Total for main centres	10 – 14%	65,000-89,000

Source: Lloyd (2006, p151)

Table 6 suggests that rates of energy hardship vary significantly throughout New Zealand, and that higher rates of energy hardship are likely to occur in the southern regions of New Zealand. This could indicate that interventions to address energy

¹² Lloyd (2006, pp145-146) modelled a typical 90m², three-bedroom, brick-veneer house, with a tiled roof, suspended wooden floor, and a window area of 25m². An annual average ambient temperature of 11°C was used in order to simulate Dunedin, and the 'British' criteria for an adequate indoor environment were used. Income and energy use data was gathered from Statistics New Zealand and Ministry of Economic Development respectively.

¹³ Lloyd (2006, 2008) defines energy hardship as the need for a household to spend more than 10% of total household income on energy expenses to maintain an adequate indoor environment.

affordability may need to be targeted regionally, or offered at different levels depending upon location within the country. Lloyd (2006, pp151-153) notes that the estimates based on his model are likely to be lower than the actual prevalence as “the modelling is based on a 90m² house, which is at the small end of the housing market, and assumes no solar shading”.

Lloyd has since updated this analysis to 2008 (Lloyd, 2008), see Table 7 below.

Table 7: Estimates of the potential prevalence of energy hardship¹¹ in the main centres of New Zealand as at 2008

Centre	Prevalence	Number of households
Auckland	14%	54,000
Wellington	24%	32,000
Christchurch	40%	54,000
Dunedin	47%	21,000
Total for main centres	23%	161,000

Source: Lloyd (2008)

Lloyd (2006, pp151-153) had noted that increases in electricity prices since 2001 “almost certainly mean that the percentage of people in fuel poverty in New Zealand is somewhat higher than that given for 2001 and will continue to rise as energy cost increases outpace income rises”. Table 7 indicates that, based on Lloyd’s (2006, 2008) modelling work, this is clearly the case as the incidence of energy hardship appears to have increased significantly over this period.

6.0 Factors Related to Household Energy Affordability

The relationship between income and energy costs is central to the issue of household energy affordability. This section briefly describes the relationship between these two factors before exploring the influence of the energy efficiency of the home and appliances, and the knowledge and practices of households.

SUMMARY

- Household income is positively correlated with household energy expenditure.
- However, as income increases, energy costs make up a smaller proportion of total household expenditure.
- Low-income households' expenditure on energy as a proportion of total income varies significantly, indicating some households spend very little on energy in absolute terms.
- Older homes tend to be colder; on average 0.15 to 0.25°C cooler for each decade older the house is.
- New Zealand houses heated by open fires tend to be the coldest on average, while those heated by enclosed solid fuel burners tend to be the warmest.
- Hot water systems in many New Zealand homes are set to high temperatures, which can result in increased energy use, and potentially lead to burns.
- When all else is held constant (building fabric, appliances, climate, etc.), energy consumption often varies significantly due to household composition and behavioural differences.

6.1 *Income and energy costs*

Figure 6 shows the relationship between total gross household income and expenditure on energy, as reported in the Household Economic Survey as at June 30, 2007 (Statistics New Zealand, 2008b).

There appears to be a weak positive association between household income and energy expenditure. The 'under \$17,600' group spends an average of \$1,368 on energy per year, while those in the highest income group 'over \$131,300' spend an average of \$2,501 (Statistics New Zealand, 2008b). While there is a positive linear relationship between household income and energy expenditure, it appears relatively shallow. Isaacs, Camilleri, French, Pollard, Saville-Smith, Fraser and Rossouw (2005, p38) report that equivalised household income is only weakly correlated with energy use (0.147, significant at the 0.05 level, 2 tailed). They fit a regression model, which controls for covariance, and found that equivalised¹⁴ household income accounts for approximately two percent of the variance in energy usage in New Zealand households (adjusted r squared 0.018). This means that approximately 98 percent of the variation in energy expenditure in New Zealand homes is due to factors other than equivalised household income. Potential reasons for this could be

¹⁴ Equivalised income accounts for the number of people living in a household, and provides a more accurate representation of the value of household income than using raw income data. For example, accounting for the number of children and adults within households.

the relatively high standing charges in New Zealand, and that a significant amount of energy use in the home is not 'discretionary'.

UK research has also found that the correlation between household income and energy use is relatively low. Dresner and Ekins (2006, p52) modelled energy expenditure using data from the 1996 English House Condition Survey and the Family Expenditure Survey for the period 1999-2001. They found that the correlation between equivalent income and fuel bills was only 0.078 (little if any correlation), indicating that factors other than household income account for the majority of the variation in expenditure on energy.

Figure 6: Annual energy expenditure by income group, as at June 30, 2007

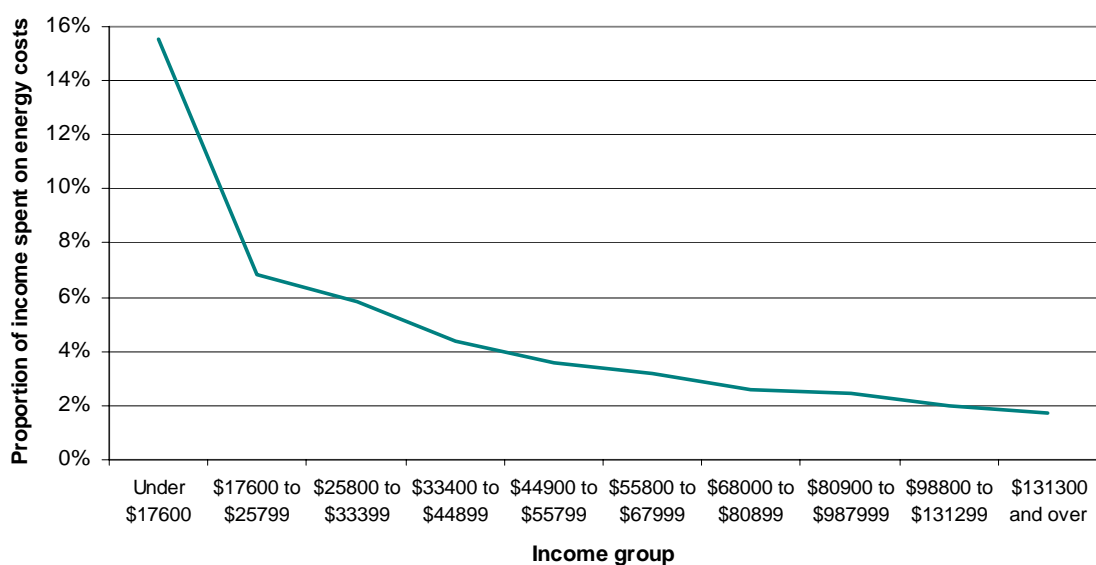


Source: Statistics New Zealand (2008b) Household Economic Survey June 30, 2007, table builder (retrieved January 30, 2009)

Notes: Income data used is net of tax

Figure 7 (following page) demonstrates how the proportion of total household income spent on energy costs decreases as income increases. This trend was also found by Bennett et al (2002, p172) for the UK (see figure 4 above).

Figure 7: Proportion of household income spent on energy costs by income group, as at June 30, 2007



Source: Household Economic Survey June 30, 2007, table builder (retrieved January 30, 2009)

Note: Income data used is net income
Mid-points in each income group have been selected to represent the average income for that group. For the 'under \$17,600' group the assumption was made that no households have a negative income. For the '\$131,300 and over' income group half of the interval for the previous group was added to \$131,300, producing an average of \$147,549.50. These are conservative assumptions, and if negative income and higher incomes were taken into account the trend would be even more extreme than shown above

Isaacs et al (2006, p5), based on an analysis of the HEEP dataset, state that

“while low income houses appear to value increased warmth, they are unable to achieve warm indoor temperatures... [and that] the higher proportionate expenditure of low income households does not assure those households a warm house or even a warm living room. Households in dwellings with very cold indoor temperatures during winter (under 16°C) appear to spend a greater proportion of their income on energy than the HEEP households overall.”

Duffy (2007, p68) notes that in the majority of studies, energy prices are inelastic in the short and long term. This means that an increase in energy prices is not likely to result in a proportionate reduction in energy use. This is not surprising as a large proportion of energy use is for 'essential' energy services such as space and water heating, cooking, and lighting. Duffy (2007) goes on to say that in order to elicit a four percent decrease in energy use, prices would need to be increased between 30 and 40 percent. This could indicate that increasing energy prices is not likely to be an effective way to reduce energy consumption.

Within a low overall coefficient of elasticity for the residential sector as a whole, particular segments are more price sensitive than others, in particular low income households. Schwartz and True (1990, in Guerin, Yust & Coopet, 2000, p61) found that despite the relative inelasticity of energy costs, when electricity prices were

increased, low income households reduced their consumption to a much greater extent than middle and upper income households. This reinforces the evidence that low income households are more susceptible to rising energy prices and are more likely to suffer the repercussions of reduced energy use (eg unhealthy indoor temperatures) when prices rise.

The actual price of energy paid by household depends on a number of factors. The price of energy varies between retailers and between different energy sources. The Electricity Commission (2007) found that households could save \$150 or more per year by switching to the cheapest electricity provider in their region, but that most did not. Households with the necessary financial resources are able to take advantage of early payment discounts while conversely low income households are more likely to face disconnection and late payment fees (Electricity Commission, 2009).

6.1.2 Cooling energy in warmer climates

While the majority of the energy affordability literature discusses energy required to maintain a suitable indoor environment in terms of heating energy, it is also worth noting that in some areas energy may also be required to cool homes. Among other things, Synott (2004, p7) notes that discussions of fuel poverty in an Australian context need to take into account “the impact of both hot and cold on the health of householders, particularly vulnerable households” and “the proportion of income spent on fuel bills (and the proportion which would need to be spent to adequately heat and cool the dwelling) for low income households”.

Heating is the dominant load in New Zealand but an increasing summer cooling load has developed, partially fuelled by the rapid increase in heat pumps (Page, 2008).

See Section 8.1 for a discussion of seasonal mortality.

6.2 Energy efficiency

This section briefly summarises how the energy efficiency of houses and household appliances relates to the issue of household energy affordability. Raising the energy performance of houses could ameliorate energy hardship. Houses with higher energy performance require less energy, and subsequently less cost, to provide the same level of service.

6.2.1 Energy efficiency of the building

New Zealand research indicates that the age of a house is strongly associated with average achieved indoor temperatures (Isaacs et al, 2006, p56). Older houses tend to be colder, with an average rate of fall in temperature of 0.15-0.25°C per decade. Isaacs et al also note that houses built since legislation made a minimum level of insulation mandatory (1978) are 1°C warmer on average than those built before this date.

The Centre for Sustainable Energy (2002) report that 86 percent of all households in England are not energy efficient (SAP rating of less than 60, on a 1-100 point scale). There is no equivalent household energy rating scheme in New Zealand, although a

voluntary Home Energy Rating Scheme (HERS) operates, administered by the Energy Efficiency and Conservation Authority. Howden-Chapman, Cunningham, Baker and Keall (2007) developed a proposed framework for quality targets for existing housing. The proposed framework outlined 14 quality targets, including the following potentially associated with household energy affordability:

- building an adequate structure
- ensuring an adequate warmth and dryness
- addressing energy efficiency.

Pears (2005, p368) notes that “in principle, and all other things being equal, heating and cooling energy use per dwelling declines as the proportion of walls, floors and ceilings shared with other dwellings increases. The higher the thermal performance of the building envelope, the less significant this trend will be”. This indicates that where buildings are not energy efficient, there may be some gain in thermal comfort from living in terraced or apartment buildings. However, when buildings are sufficiently energy efficient there is no significant difference between building types.

Ryan, Burgess and Easton (2008) note that it is difficult and expensive to improve the energy performance of 1960s and early 1970s multi-house units, and art deco buildings in New Zealand.

6.2.2 Energy efficiency of household appliances

In addition to the building envelope, the energy efficiency of household appliances is an important factor in the amount of energy used within the home.

Isaacs et al (2006, p55) found that the type of heating appliance used in a house had implications for average achieved temperatures. Houses heated by open fires were the coolest with an average of 16.0°C, while houses heated by enclosed solid fuel burners were the warmest with an average of 18.8°C.

There is considerable use of unflued gas heating in New Zealand (Ministry for the Environment, 2005a). The Ministry for the Environment states that around three quarters of gas used for residential heating is used in an unflued appliance. Although portable unflued gas heaters can operate as a budgeting mechanism (filling a gas cylinder is a fixed cost), other forms of heating are more cost effective (Consumer, 2009). The gases emitted from unflued gas appliances are associated with poor health outcomes (for more information see Section 8.4).

As noted above (see Section 4.4), water heating comprises approximately 29 percent of total household energy use (Isaacs et al 2006). Isaacs et al (2006) goes on to note that many New Zealanders may be using more energy than they need to for water heating. Most hot water systems are low pressure storage systems, heated by electric cylinders. More efficient, cost effective heating technologies such as solar water heating, instantaneous heat systems and heat pumps have a low market share. Water heating costs are further increased by excessive hot water cylinder temperatures.

Shen (2004, p43-44) notes that water heating systems at high temperatures can result in high standing losses due to the large amount of energy required to maintain the water at this temperature, and there is potential for accidental burns. In a study of selected Dunedin and Southland homes, Shen found hot water temperatures as high as 99°C. Isaacs et al (2006, p7) report that tap temperatures of 65°C were found in

41 percent of 135 litre cylinders, 27 percent of 180 litre cylinders, and that 1.1 percent of households in the HEEP study had hot water temperatures over 90°C.

Isaacs (2004, p7) reports that approximately 18 percent of fridges are faulty in some way and that around 10 percent of fridges are faulty to the extent that replacement would provide real benefits in terms of reduced energy consumption.

Minimum energy performance requirements for water heating systems in new houses were introduced to the Building Code in 2000. The Building Code sets minimum requirements only, and the requirements for cylinders have now been superseded by Minimum Performance Standards.¹⁵ There are no Building Code requirements for residential lighting or space heating/cooling appliances (Department of Building and Housing, 2007).

6.3 Household composition and occupant behaviour

The effect of occupants' behaviour on household energy consumption is a topic on which little research has been done, with much of the research on household energy affordability exploring the issue of income and energy expenditure.

Research indicates that energy consumption varies between household types, size and composition of the household. In particular, the number of people in the household has been found to be positively correlated with level of energy use (Hirst & Goeltz, 1984, Johnson-Carroll et al 1987, Morrison et al 1978, Ritchie et al., 1981; all in Guerin, Yust & Coopet, 2000, pp62-63). Isaacs et al (2005, p24) note that household size is positively correlated with total energy use ($r=0.36$, $p=0.001$). They fit a regression model, which controls for covariance, and found that household size accounts for around 17 percent of variance in household energy expenditure in New Zealand.

Isaacs et al (2005, p25-26) report that age is negatively correlated with energy use (-0.271 , significant at the 0.05 level, two tailed), meaning that as people age they use less energy. Guerin, Yust & Coopet (2000, p61) summarise international research into the effect of the age of members of a household, stating:

“Morrison et al. (1978) found that households in the middle life-cycle used more energy than younger or older families. Fritzsche (1981) found significant differences in energy consumption by stage of the family life-cycle... Total energy consumption increases with the middle life-cycle stage (specifically middle-age married households with children), which consumes the most total energy. When children leave the family, energy consumption decreases throughout the remaining stages of the family life-cycle.”

This difference in findings is likely to be due to how the various researchers defined the age of the household. Isaacs et al (2005) used the age of the youngest usually resident member of the household. So while the research Guerin et al (2000) summarise indicates households with children are typically in the 'middle lifecycle stage', Isaacs et al would classify them as 'pre-school age' or 'school-age' households. This may indicate that presence of children in a household is a more

¹⁵ Minimum Energy Performance Standards for new appliances at time of sale, administered by the Energy Efficiency and Conservation Authority. For more information see <http://www.eeca.govt.nz/standards-and-ratings/minimum-energy-performance-standards-and-labelling>

useful indicator of high energy use than the relative stage in the lifecycle of the 'head of the household'.

How households use energy, in particular heating energy, in their home also plays an important part in household energy affordability. For example, households where the occupants are home during the day are likely to require additional energy, and some houses may avoid heating their homes in order to be able to afford their energy bills.

Mulvey (2008, p4) reported that the income of low income older people in the United States is not keeping up with increases in energy costs, stating that "average annual energy-related spending for low-income households (after adjusting for inflation) has increased only 5.9% since 2000, compared to 20% for higher-income households... this difference may reflect lower-income households changing their behaviour in response to rising energy costs."

Guerin et al (2000, p54) provide the following summary of some early research into the effects of occupants' behaviour on household energy use:

"Princeton's Twin River experiment (Seligman et al 1978) was one of the first studies to examine the role of an occupant's behaviour as it related to energy usage. In townhouses with identical floor plans and appliances, the variation in energy consumption for space heating, one place sometimes twice as much as another, was attributed to the resident rather than to the structural features. Seligman et al (1978) also found that energy usage by new occupants of the house could not be predicted based on past occupant usage patterns. Finally, even after all the townhouses had been retrofitted with conservation measures that had given the occupants up to 25% energy savings, the variation in energy consumption among the houses remained almost the same as it was before the retrofits took place."

7.0 Vulnerable Populations

Rates of energy hardship vary between different population groups, based on factors related to both the quality of the housing stock, and the economic and demographic composition of households. This section summarises research exploring the relationship between household characteristics and prevalence of energy hardship.

Specific estimates of prevalence for sub-groups vary widely between countries and studies, partially due to differences in the definition and measurement tool, but also due to differences between populations. As a result, the exact size of the effects should be seen as less important than the presence of an effect.

SUMMARY

- International research indicates that the following groups are more likely to experience energy hardship than the wider population:
 - Those living in older/less energy efficient homes.
 - Tenants (relative to owner occupied homes).
 - Single person households, and households with six or more occupants.
 - Low income households.
 - Older people.
 - Sole parents.
 - Rural households.
- Landlords appear to have a more positive opinion of the condition of their properties than both their tenants and independent inspectors.

Note:

While prevalence of energy hardship is important in determining specific population groups particularly at risk, it is also important to consider the absolute size of the energy hardship problem within sub-groups. For example, while sole parents have a high rate of energy hardship, there are far fewer sole parents in energy hardship than there are older people, due to the relative sizes of each of these population groups.

7.1 Housing stock

7.1.1 House condition

The relationship between poor housing and energy hardship is very clear from the literature. Sustainable Energy Ireland (2003, p30) report that, based on a national survey, older dwellings are more likely to be occupied by those experiencing energy hardship than newer dwellings. This is not surprising, as Quigley (2006, p18) notes, older properties in the poorest condition are most likely to be the only option for many low income households. As noted above (Section 4.2), New Zealand homes built prior to the 1978 legislation requiring insulation of homes are on average colder and more expensive to heat (Isaacs, 2004; Camilleri, French & Isaacs, 2008).

7.1.2 Housing tenure

Sustainable Energy Ireland (2003, p.30) report that tenant households have far higher rates of energy hardship (20.9 percent) than owner occupied housing (4.1 percent). They also note that Local Authority housing has a higher rate of energy hardship than private rental properties. However, for households in energy hardship, it is a *persistent* problem for a greater proportion of private rental households (44.1 percent) than Local Authority rental households (19.3 percent). It is important to keep in mind that a higher proportion of energy hardship within a population group does not necessarily result in a large number of absolute cases of energy hardship. While the tenant households exhibit a far higher rate of energy hardship than owner-occupiers, there are fewer tenant households in energy hardship than owner-occupier households due to the relative sizes of each of these population groups.

It is not surprising that rental properties experience a greater incidence of household energy affordability problems, as the New Zealand Ministry for the Environment (2005a, p23) notes:

“a tenant is unlikely to change to cleaner heating when it means investing in (and possibly increasing the value of) someone else’s property, a property in which they may not always live. Also, a tenant may not have permission to make such a change without the landlord’s consent. This kind of investment decision rests with the non-resident owner/landlord of the property. A number of considerations that are likely to inhibit change will probably influence the owner/landlord, including the desire to limit expenditure on their property investment.”

This point could be made for other expenses, such as insulation and double glazing.

New Zealand’s rate of house ownership is falling and the number of renters is increasing. Between 1991 and 2001, the proportion of New Zealand households owning their dwellings either with or without a mortgage, or in a family trust, decreased from 74 percent to 68 percent (Ministry of Social Development, 2008). By 2006, this rate decreased further to 67 percent. This decrease between 2001 and 2006 occurred for age groups from 25 to 74 years old, but was greater for the 35 to 54 year-old age group. The only age group to experience a significant increase in home ownership was the 75 year-old and over age group.

7.1.3 Private landlords

UK research carried out by the Department for Communities and Local Government (2008, p1) which found that UK landlords tend to have an overly optimistic view of the condition of their properties, noting that:

“landlords and agents generally felt that the property they were letting was in good condition. The landlords or agents of more than one in five (22%) rated the property as in ‘excellent condition’ (nothing needs doing). A further 56% of properties were rated as ‘good’ (only minor problems) and 16% as fair (some problems, but not too many). Sample properties rated as poor or very poor (quite a lot of major problems) accounted for only 3%.... According to the EHCS surveyor’s assessments, some 40% of dwellings included in the sample did not meet the decent homes standard.”

Saville-Smith and Fraser (2004, p12, in Povey & Harris, 2005, p7) report that “almost 70 percent of landlords had no ‘known’ budget for maintenance expenditure... [and] among the minority of landlords that do set aside or forecast a maintenance budget, the budgeted amounts are small”. In contrast, Povey and Harris’s (2005, p.17) findings show that 57 percent of tenants reported that their property needed urgent repairs. This indicates that landlords and tenants of low income housing may often have very different opinions on the quality of the building, or that some landlords may not be prepared to address known problems with their rental accommodation.

Findings from a recent New Zealand survey found that almost half of the landlords surveyed reported they would retrofit their property with government assistance, however nearly one quarter reported they would not retrofit their properties even given this assistance (Saville-Smith, 2008, p17). Saville-Smith’s research also indicates that very few landlords are aware of existing financial assistance. Around 40 percent of landlords surveyed believed there was financial assistance available, however very few knew where to access this assistance, with only 17.5 percent identifying local government, 5.7 percent identifying EECA, and 2.4 percent identifying local energy trusts as sources of assistance.

Saville-Smith (2008, p2) notes that “homeownership in New Zealand is falling and landlord decisions are likely to become increasingly important in determining the thermal performance of the housing stock and the conditions under which many households live”.

7.2 Demographic and economic factors

7.2.1 Household composition

Department for Business, Enterprise and Regulatory Reform and the Department for Environment, Food and Rural Affairs (2008a, p53) report that single person households are more likely to be fuel poor than households with two or more people, and note that this is most likely due to lower income and a higher incidence of under-occupying their home. Research also indicates that separated, divorced and widowed households had a slightly higher rate of fuel poverty (28.2 percent) than all single person households (22.6 percent) (Sustainable Energy Ireland, 2003, p28).

Healy and Clinch (2004, p212) found similar effects for household size in Ireland, but noted that “the results also point to a U-shape relationship ... with an increasing incidence of fuel poverty... in very large households (those with six or more persons)”.

Research from the General Social Survey Victoria 2004 (Australian) (Dufty, 2007, pp66-67) found that compared with other ‘household types’ sole parent households have the highest incidence of fuel poverty (36.9 percent) compared with the entire population (12.5 percent). This finding is backed up by research from Ireland (Sustainable Energy Ireland, 2003, p.24) which also noted that sole parent households where all children are aged under 16 were more likely (19.2 percent) to be living in fuel poverty than sole parent households containing at least one older child (11.8 percent).

There were 1.45 million households in New Zealand at the 2006 Census. Of these, 23 percent were one person households, 12 percent sole parent households, 28 percent couples without children, 20% couples with children, three percent contained

more than one family and five percent comprised a group of individuals (Ministry of Social Development, 2008). Couple only and one person households are the fastest growing household types in New Zealand and are projected to increase the most over the next 15 years (Ministry of Social Development, 2008). Population ageing is the major factor behind the growth of one person households but delayed marriage, divorce and changing lifestyle preferences are other contributing factors. Increasing numbers of single adult households could indicate that greater numbers of households will be at risk of energy hardship.

7.2.2 Low income

Unsurprisingly, research indicates that low income households are more likely to be in fuel poverty than higher income households (for example, Dufty, 2007, p66).

Quigley (2006, p19) notes that low income households are much more likely to miss payments on their energy bills, and that “paying a reconnection charge to get their power back on compounds their problems, further reducing funds for food, health care, and taking part in community activities”.

Section 6.1 earlier illustrated the relationship between income and expenditure, using New Zealand Household Economic Survey data.

7.2.3 Older people

Older people make up a large proportion of those in energy hardship, with UK research indicating that more than half of all fuel poor households contain an ‘older person’ (DEFRA & DTI, 2001, in Wright, 2004, p489). Cold homes place stress on older people as they have less robust thermoregulatory systems and typically spend more time inside their homes (Howden-Chapman, Matheson, et al 2007, p1).¹⁶

Dufty (2007, p66) states that:

“in terms of energy consumption patterns and energy expenditure levels for lower income groups, research has demonstrated that pensioner groups consume energy at a rate below average household consumption. Conversely, as a proportion of their weekly expenditure, they expend almost double the amount compared to the average household. This highlights the disproportional impact price increases will have on this group.”

There is evidence from qualitative research in the UK that older people hold misguided views about heating, ventilation and their relationship with health outcomes. Wright (2004, p495) reports that some older respondents felt their adult children kept their homes “too warm”, noting that they felt this made people more susceptible to illness. Other attitudes and behaviours commonly found by Wright were turning off heating for periods during the winter to save money and because “economising on heat was a virtue”, isolating and heating only the living space in a house, and keeping bedroom windows open all night for the ‘health benefits’ of breathing cold air. Misconceptions such as these could contribute to winter mortality rates, and serve as additional barriers for seeking help with paying for heating energy.

¹⁶ Burholt and Windle (2006) note that previous research indicates that older people spend between 70-90 percent of their time in their homes.

The Ministry of Social Development (2008) notes that New Zealand's population is ageing and that the over 65 age group is projected to make up a larger proportion of the total population. Given that older people are more susceptible to the negative health outcomes associated with cold, damp housing (see Section 8.0), the ageing population could result in substantial ongoing health care costs.

7.2.4 Ill health and disability

Kober (2005) notes people with disabilities and long term illness are more vulnerable to cold and damp. Cold, for example, can exacerbate pain or aggravate existing impairments.

Research indicates that people with disabilities are more likely to be on low incomes, and as noted above, low income is strongly associated with energy hardship (see Section 6.1). In the UK, almost half of adults aged 45-64 in the poorest fifth of the population have a limiting long-standing illness or disability, twice the rate for those on average incomes (Palmer, Carr, Kenway, 2004). The UK Government's annual Households Below Average Income (HBAI) report has consistently indicated that families with one or more disabled member are at greater risk of low income than families without a disabled member (Kober, 2005).

7.2.5 Rural households

Scottish research indicates that rural households may be more likely to be living in fuel poverty than urban households. Using the '10 percent of income spent on energy' threshold, HCST (2002, in Illsley, Jackson & Lynch 2007, p21) report that 21 percent of rural Scottish households are in fuel poverty, compared with only 13 percent of all Scottish households. The National Audit Office (2003, p19) in the UK report that take-up of Warm Front, a major intervention aimed at reducing fuel poverty, appears to be very low among rural households.

8.0 Health Outcomes

There is clear evidence of associations between cold, damp homes and certain types of illness and excess winter mortality and morbidity (Morrison and Shortt, 2008, p794).

The relationship between energy hardship and poor health outcomes is typically based on the assumption that households living in energy hardship will respond by adopting either or both of the following coping mechanisms (Centre for Sustainable Energy, 2002, p4):

- They cut back on energy use in an attempt to maintain manageable energy bills. This leads to cold homes and damp and/or mould growth – key determinants of poor health.
- They run up high energy bills to try and maintain adequate levels of warmth. This contributes to general indebtedness or the need to cut back on other essential items such as food and clothing. This can also have health consequences, for example depression.

Research has established specific temperatures associated with increased risk of specific health outcomes. Wallis (2003, p15) notes that once temperatures fall below 16°C, resistance to respiratory disease begins to diminish. Between 9°C and 12°C core body temperature begins to drop and blood pressure rises, increasing the risk of heart disease.

SUMMARY

- Excess winter mortality appears to be higher in countries with milder winters, thought to be due to less protective measures being taken in cold weather.
- Ischaemic heart disease, cerebrovascular disease and respiratory disease account for approximately three quarters of excess winter mortality.
- Older people, women and those living in older homes appear to be more at risk of excess winter mortality.
- High temperatures have also been shown to increase mortality rates, indicating a 'U-shaped' relationship between ambient temperature and mortality rates.
- Damp indoor spaces and mould are strongly associated with upper respiratory tract infections, coughs and wheeze and asthma in previously sensitised individuals.
- The use of unflued gas heaters can have a significant negative impact on health.

8.1 Seasonal mortality

Seasonal mortality refers to peaks in mortality rates which occur at regular cycles throughout the year, and which are largely attributed to changes in ambient air temperature. There is clear evidence that winter mortality is higher in countries with milder winters than in those with the coldest winters (for example, World Health Organisation, 2006, p11; McKee, 1989, in Wilkinson et al 2001, p1; The Eurowinter Group, 1997, pp1344-1345; Davie, Baker, Hales & Carlin, 2007). The Eurowinter Group (1997, p1344) found that protective measures against cold varied widely

between different European countries. They found that, at a standard outdoor temperature of 7°C, compared with people living in countries with the coldest winters, those living in countries with milder winters were:

- less likely to heat bedrooms
- more likely to heat living areas to a lower temperature
- less likely to wear a hat, jacket, gloves or trousers (for women) outdoors
- more likely to stand still and shiver when outside.

The Eurowinter Group conclude that (1997, p1345):

“the associations shown in the results between mortality and protection against cold stress strongly suggest that excess winter mortality could be reduced substantially by improved protection from cold - particularly in countries with warm winters where the need for cold-avoidance was less obvious, and measures taken against it less effective. Taken with previous evidence of substantial winter mortality in people with fully heated housing but outdoor exposure, the results imply adverse effects of both outdoor and indoor cold on mortality.”

Approximately half of all excess winter mortality is attributable to ischaemic heart disease and cerebrovascular disease, with respiratory disease accounting for about half of the remaining deaths (Davie, Baker, Hales & Carlin, 2007). Healy (2006, in World Health Organisation, 2006, p67) reports that “the commonly-held assertion that pneumonia is a major cause of excess winter mortality is erroneous, with less than five percent of excess winter deaths caused by same”.

Wilkinson, et al (2001, p1) report that the scale of the excess winter mortality problem is around 40,000 deaths per annum in the UK. The vast majority of excess winter death in the UK occurs in the over 65 population (Healy, 2006, in World Health Organisation, 2006, p.68; Wright, 2004, pp488-489). Wallis (2003, p.14-15) notes that between 20,000 and 50,000 older people die every year from cold related illnesses, stating that for every 1°C below the winter average in the UK, there are an extra 8,000 deaths. “Thus it is not just the very coldest days that are associated with higher death rates, [which can be seen] at quite moderate falls in temperature” (Wilkinson, et al 2001, p1). This is supported by the finding that hypothermia is the cause of fewer than 200 deaths per annum and accounts for less than one percent of excess winter deaths (Collins, 1983, in Centre for Sustainable Energy, 2002, p.9).

Table 8 below demonstrates the relative risk of excess winter mortality by selected variables for the UK, based on 1986-1996 data (Wilkinson et al 2001, pp8-9). Table 8 also indicates a significant relationship between the age of a house and the likelihood of excess winter death for its occupants, although this effect is smaller than that of the age of occupants.

Table 8: Relative risk of excess winter mortality in the UK between 1986 and 1996

	Risk (95% CI) relative to baseline group	P-value for trend
Age group		
0-44	1.0	<0.001
45-64	1.17 (1.03-1.34)	
65-74	1.20 (1.05-1.36)	
75-84	1.21 (1.07-1.46)	
85+	1.28 (1.13-1.46)	
Tenure		
Housing association ¹⁷	1.0	0.008
Local authority	1.02 (0.96-1.08)	
Owner-occupied	1.06 (1.00-1.12)	
Private rented	1.06 (0.98-1.14)	
Property age		
Pre-1850	1.0	0.001
1850-99	0.98 (0.88-1.09)	
1900-18	0.97 (0.87-1.08)	
1919-44	0.98 (0.89-1.09)	
1945-64	0.97 (0.87-1.07)	
1964-80	0.91 (0.82-1.01)	
Post-1980	0.90 (0.79-1.02)	
Condition: dampness		
Satisfactory	1.0	0.03
Acceptable	1.07 (1.01-1.13)	
Defective	1.05 (0.98-1.13)	
Seriously defective	1.04 (0.91-1.18)	

Source: Wilkinson, Landon, Armstrong, Stevenson, Pattenden, & McKee (2001, pp8-9)

Based on data for the period 1980-2000, Davie, Baker, Hales and Carlin (2007) report that mortality rates in New Zealand were on average 18.4 percent higher in winter than the rest of the year. Davie et al (2007) also found that women had a nine percent higher incidence of winter mortality relative to men. Davie et al. (2007) did not find any significant difference in winter mortality prevalence based on ethnicity, NZDep score or geography.

Wilkinson, Pattenden, Armstrong, Fletcher, Kovats, Mangtani & McMichael (2004, p6) note that the association between socio-economic status and excess winter mortality is weak, with risk of excess winter mortality widely distributed among elderly people rather than being concentrated in the most disadvantaged households. This indicates that addressing energy hardship may not necessarily result in dramatic reductions in rates of excess winter mortality. Telfar Barnard, Baker, Hales and Howden-Chapman (2008, p213) conducted a systematic review of literature on the relationship between excess winter events and socio-economic status, and concluded that there was “little evidence of a relation between socioeconomic status and excess winter health events, and only limited evidence that such events are associated with housing quality”.

¹⁷ Housing Associations are independent, not-for-profit agencies that provide low-cost housing for people ‘in need’.

Wilkinson et al (2001, p1) report that the relationship between temperature and mortality is U-shaped, with deaths resulting from both high and low ambient temperatures. This finding supports the concerns about inability to afford energy required to sufficiently cool a dwelling in high temperatures (see Section 6.1.2 above).

Healy (2006, in World Health Organisation, 2006, p71) describes how the effect of cold on mortality rates varies by geography/climate:

“The exposure depends on the geography/climate. A 1-2% rise in all-cause mortality per 1°C fall in temperature is a reliable dose-response function for ‘median’ climates in Europe. Very cold climates demonstrate lower dose-response rates, typically less than 1% per 1°C fall in temperature. Milder, Mediterranean climates demonstrate higher exposure rates of 2% or more.”

While research has established the level of excess winter mortality, Wallis (2003, p14) makes an important point, noting that many more households will end up living in cold damp homes throughout the winter. While some of these households will appear in winter morbidity numbers, many more will remain uncounted as medical care often presents an additional expense.

8.1.1 Contribution of outdoor exposure to low temperatures

The extent to which excess winter events can be attributed to indoor, as opposed to outdoor, temperatures is not clear. Healy (2006, in World Health Organisation, 2006, p68) states that

“the proportion of cold-related excess deaths resulting from indoor, rather than outdoor, cold stress has been put at between 44 and 50%. However, there is little corroboration of these findings and limited scientific backing... Cold stress from indoors is probably accountable for between a third and a half of all excess winter deaths.”

Wilkinson et al (2001, p17) explored the interaction between indoor and outdoor temperature on excess winter mortality, finding that:

“the relationship between outdoor temperature and mortality was steeper among residents of intrinsically cold homes than among those living in warmer homes. In other words, for each degree Celsius fall in outdoor temperature, the percentage rise in mortality is greater in those living in cold homes (the rise was about 2.8% per degree Celsius in the coldest 10% of homes and 0.9% in the warmest 10% of homes).”

8.2 Excess winter morbidity

In addition to contributing to seasonal mortality, research has established associations between energy hardship (via cold, damp housing) and specific health outcomes.

The National Heart Forum (2003, in Shortt and Rugkasa, 2007, p100) summarises recent research, noting that there is evidence to support associations between cold housing and:

- respiratory illness
- increased blood pressure
- risk of stroke
- worsened arthritis
- increased likelihood of accidents in the home
- social isolation
- impaired mental health
- and adverse effects on children's education and nutrition.

Healy (in World Health Organisation, 2006, p67) reports that cold homes can result in depression. Smith et al (1993, in, Dunn, Hayes, Hulchanski, Hwang & Potvin, 2004, p19) notes that "living in a substandard dwelling represents an independent and additive source of stress to the lives of low income residents". Green and Gilbertson (2008, p13) reported that households who stated that it was 'very difficult' for them to pay their energy bills were 2.5 times more likely to be suffering from stress than those who find it 'very easy' to pay these bills. This research also found that "occupants maintaining bedroom temperatures at 21°C were 50% less likely to suffer high levels of psychological distress than those with temperatures less than 15°C" (p14).

In a report summarising the prevalence and types of hazards within UK homes, the Department for Communities and Local Government (2008, p4) reported that cold housing is rated among the most common 'category 1' hazards.¹⁸ Accidents in the home are more common in winter, in part due to the effect of lowering body temperature on mental functioning, movement and sensation (Centre for Sustainable Energy, 2002, p10). Raw et al (2001, in Centre for Sustainable Energy, 2002) report that finger strength and manual dexterity decrease at lower temperatures.

8.3 Dampness and mould

Damp and mould in homes is a widespread problem. Zock, et al (2002, in Institute of Medicine, 2004, p46) conducted a survey across 18 developed countries including New Zealand (total n = 16,687) which included questions relating to indoor dampness and mould. Zock et al estimate that 12% of households have experienced water damage in the previous 12 months, and 22% experienced mould or mildew damage in the previous 12 months. Povey and Harris (2005, p22) report that dampness was found in approximately 18% of living rooms, and 24% of bedrooms in Dunedin households.¹⁹

The World Health Organisation (2006, p15) reports that there is strong evidence of an association between dampness and cough, wheeze, onset of new asthma cases and worsening of symptoms in individuals with pre-existing asthma. The Institute of Medicine (2004, pp9-10) conducted a meta-analysis of research into the association between mould or damp indoor spaces and poor health outcomes.

¹⁸ Category 1 hazards are defined as posing "the most severely rated risk to a potential occupant who is most vulnerable to that hazard. (The property is not assessed on the basis of actual occupants)" (Department for Communities and Local Government, 2008).

¹⁹ Due to a low response rate and small sample size, these findings should be treated as indicative as opposed to robust.

Association between damp indoor spaces and health outcomes:

- sufficient evidence of an association
 - upper respiratory tract symptoms
 - cough
 - wheeze
 - asthma symptoms in previously sensitised individuals
- limited or suggestive evidence of an association
 - dyspnoea (shortness of breath)
 - lower respiratory tract illness in otherwise healthy children
 - development of asthma in non-sensitised individuals.

Association between presence of mould or other agents and health outcomes:

- sufficient evidence of an association
 - upper respiratory tract symptoms
 - cough
 - wheeze
 - asthma symptoms in previously sensitized individuals
- limited or suggestive evidence of an association
 - lower respiratory tract illness in otherwise healthy children.

The Institute of Medicine (2004, pp48-50) note that within reason, *presence* of damp and mould is a more important factor in determining risk of poor health outcomes, than a measurement of the *extent* of damp and mould. There is disagreement in the literature as to whether 'occupant reported' or 'investigator assessed' mould prevalence is a better estimate of the extent of indoor damp and mould. The Institute of Medicine (2004, p48) notes that:

"Douwes et al. (1999) found that occupants' reports of damp spots or mould spots were better correlated with a measure of indoor mould than investigators' reports of these visible signs. Bornehag et al. (2001) concluded that, although in most studies occupants had reported more dampness than investigators had, this was due to the occupants' longer time perspective than the investigators' 'snapshot' observations. A conflicting study by Williamson et al. (1997) found that occupants reported dampness less often than trained surveyors."

The presence of damp in a home is not a direct cause of ill-health, but largely determines the presence or strength of exposure to dust mites, microbial growth, cockroach infestation and potentially chemical emissions from building materials and furnishings (The Institute of Medicine, 2004, p1).

8.4 Unflued gas heaters

Anecdotally, some low income families in New Zealand use portable unflued gas heaters as a main heating source because expenditure is able to be monitored more easily than with electric heaters. Use of gas bottles enables lowincome households to pay in advance and allows households to ensure they don't 'overspend' on energy costs. This section briefly outlines research on the health outcomes of indoor use of unflued gas heaters.

Due to their contribution to poor health outcomes, unflued gas heaters are banned in Canada and parts of America, and 'effectively banned' in Victoria and South and Western Australia (Wilson, 2006, p48). Unflued gas heaters emit substances known to result in poor health outcomes, including carbon monoxide (CO) and water vapour

(Quigley, 2006, p22), and nitrous dioxide (NO₂) (Pilotto, et al, 2003, in Gillespie-Bennett, et al 2008, p2).

Water vapour given off by combustion contributes to high humidity levels within a home. CO is a lethal, odourless gas which can accumulate within homes when unflued gas appliances are not properly ventilated while in use.

Gillespie-Bennett et al (2008, p2) summarise the evidence of associations between exposure to NO₂ and poor health outcomes, stating:

“indoor NO₂ has been associated with effects on the airway, including the enhancement of airway responses to allergens (Tunnicliffe et al., 1994; Barck et al., 2002). While other studies have shown that NO₂ exposure can increase asthma symptoms in children (Belanger et al., 2006) and prolong the severity of viral associated asthma exacerbations (Chauhan et al., 2003).”

Hoskings (2003, in Wilson, 2006, p5) estimates that residents of houses with unflued gas heaters are 1.4 times more likely to develop lower respiratory tract infections than houses using other heating sources. Hoskings goes on to note that this finding indicates approximately nine percent off hospitalisations for child asthma during 1996 were the result of household use of unflued gas heaters.

Quigley (2006, p22) notes that while unflued gas heaters are relatively cheap to buy, they are more expensive to run. Some households using unflued gas heaters may incorrectly think they are using a cheap heating source. Qualitative research by Dunn, Howden-Chapman, Viggers (2003, in Wilson, 2006, p15) found that some Work and Income case managers were advising clients to purchase unflued gas heaters, stating that they were cost effective and a viable source of heating. Recent advice issued by Work and Income (Ministry of Social Development, nd) emphasises the risks associated with using unflued gas heaters and provides advice for how to use these appliances safely if households have no other space heating appliance.

9.0 Interventions

This section outlines some of the interventions that have been put into place to address the issue of energy hardship. Note that this section is not an exhaustive list of interventions to date.

SUMMARY

- Early interventions in the UK were based on direct winter payments to target groups in order to assist with energy bills. This approach has since been criticised as less effective than increasing the energy efficiency of homes and heating appliances
- Benefit entitlement checks have been found to be highly effective, typically offered to recipients of energy efficiency interventions
- In the UK energy providers are required to meet specific outcomes, including increasing energy affordability for low income households, and have been exceeding targets to date
- Internationally, policies have been put in place to ensure energy retailers work with low income households to attempt to avoid disconnection
- Pre-payment meters are used by many households in energy hardship in the UK, with many incorrectly believing they are paying less for their energy than those using other payment methods
- Improving the energy efficiency of homes via improving the thermal envelope/air-tightness of homes, and energy efficiency of appliances is widespread internationally, and has been shown to reduce heating energy required
- Smart metering and energy tariffs have been shown to result in more 'energy efficient' behaviour

9.1 *Income-based interventions*

9.1.1 Income subsidy

The UK Government provides winter fuel payments of between £125 and £400 to vulnerable consumers, mostly pensioners (The Pension Service, nd). Winter fuel payments provide immediate assistance to these vulnerable households facing additional energy costs during winter.

Direct payments to low income households have been criticised as alleviating immediate problems, but not addressing the underlying problem. Wilkinson et al (2001, p21) note that improving the energy efficiency of homes is a better solution than supplementing the income of low income households, because:

- it is a more lasting solution
- it is easier to maintain indoor temperatures once such improvements have been made
- such improvements favour overall reduction of energy use with wider environmental benefits.

Sustainable Energy Ireland (2003, p13) support this position, noting that “placing warmth in a thermally inefficient home is a bad investment” and that “a long term

solution to fuel poverty revolves around removing house thermal inefficiencies". The Electricity Commission (2008, p73) in New Zealand notes that "measures to address general (income) poverty may not be the best approach to deal with energy affordability issues".

9.1.2 Benefit entitlement checks

Benefit entitlement checks are another income-based intervention. BERR and DEFRA (2008a, p24) report that during the 2007-2008 year benefit entitlement checks were offered to UK households taking part in an energy retrofit intervention, and that of the 50,000 applicants during this period, "30% located a benefit to which the client was eligible but not currently claiming. The average value of these unclaimed benefits was £28.43 per week, or £1,478 per year". Energy Action Scotland (2007, p4) report similar results for a benefit entitlement check scheme in Scotland, where those who were found to be entitled to additional benefits received an average of £1,400 per annum.

9.2 Interventions addressing energy expenditure

9.2.1 Obligations on energy providers

The UK Government has undertaken significant regulatory reforms to ensure energy suppliers invest in energy efficiency. The Energy Efficiency Commitment (EEC), now known as the Carbon Emissions Reductions Target (CERT), places obligations on electricity and gas providers to achieve energy savings targets reviewed every three years. The UK Office of Gas and Electricity Markets (OFGEM) (2008) reports that during phase two of the EEC, which required certain gas and electricity suppliers to achieve energy savings targets between April 1, 2005 and March 1, 2008, energy suppliers exceeded their overall targets by 57 TWh. Of the overall activity, approximately 44 percent were in the 'priority group' (made up of low income and elderly consumers), which was targeted predominantly through the delivery of insulation measures. DEFRA (2009a) note that

"under CERT, energy suppliers must, by 2011, deliver measures that will provide overall lifetime carbon dioxide savings of 154 MtCO₂ - equivalent to the emissions from 700,000 homes each year. Suppliers must focus 40% of their activity on a 'Priority Group' of vulnerable and low-income households, including those in receipt of certain income/disability benefits and pensioners over 70. By increasing the energy efficiency of [Great Britain] households, CERT will not only help households from falling into fuel poverty but is also expected to help alleviate fuel poverty"

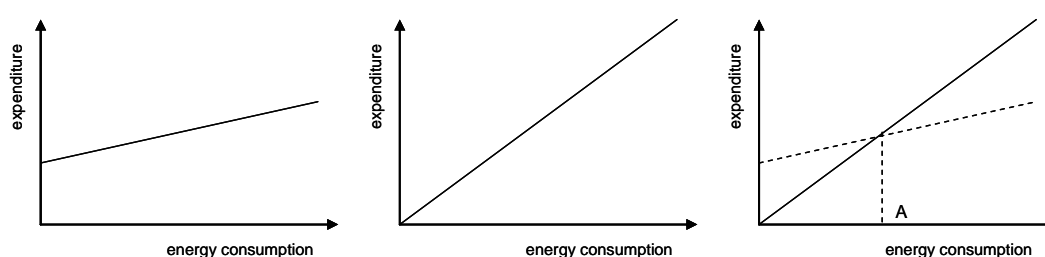
While reports published by OFGEM indicate that the EEC contributed to the UK's Fuel Poverty Strategy, there is no attention paid to the issue of cost recovery and it is therefore difficult to fully understand the economic response applied by gas and electricity suppliers to the introduction of the targets (ie whether or not customers were affected by the introduction of higher energy costs).

9.2.2 Energy pricing structural changes

Standing charges typically make up a larger proportion of total energy expenditure for low energy consumption households than households with high energy usage (Dufty, 2007, p69). Standing charges effectively result in many low income households having to pay more per unit of energy than households that consume a greater amount of energy.

Bennett, Cooke and Waddams-Price (2002, p175) describe the implications of British Gas removing the fixed standing charge from their pricing structure and putting in place a constant price per unit of energy consumed. Figure 8 below outlines the changes in energy pricing structure.

Figure 8: An example of changes in energy price structure



Source:

Adapted from Bennett, Cooke and Waddams-Price (2002, p175)

Notes:

These figures do not represent actual data, and are intended to describe the general changes to the energy pricing structure resulting from abolition of standing charges

The first chart illustrates the previous tariff structure, with a fixed standing cost. The second chart illustrates the new structure, which has omitted the standing cost, and increased the cost per unit of energy. The third figure overlays these two cost structures, with 'A' used to represent the level of energy consumption under which consumers will be 'better off', and above which consumers will be 'worse off'. Bennett, et al (2002, p183) go on to note that while this restructuring benefits low consumption households, these are not necessarily fuel poor households, and that many fuel poor households will be worse off due to this change.

Bennett, et al (2002, pp168-169) note that part of the initial UK push to eradicate fuel poverty was to privatise and increase competition in the domestic energy supply market, but that this has failed to provide the benefits that were anticipated. Bennett et al. goes on to say that there is now concern that "those least able to pay may also have fewer opportunities to gain from competition".

9.2.3 Low fixed charges

The Ministry of Economic Development (2004) notes that low fixed charge regulations were introduced in New Zealand in 2004 with the purpose of assisting low-use domestic consumers and encouraging energy efficiency. The Electricity (Low Fixed Charge Tariff Option for Domestic Consumers) Regulations 2004 require networks and retailers to provide a low fixed charge tariff option to domestic consumers who consume less than 8,000 kWh of electricity per annum at their primary dwelling.

The Electricity Commission (2006) notes that:

“many domestic consumers have undoubtedly benefited by paying significantly less for their electricity by being on the low-user option, however, all the remaining domestic electricity consumers have been paying more to subsidise them...The regulations have largely failed to consistently assist those consumers that are in the greatest need of assistance. In fact, many more ‘needy’ consumers have actually been penalised by the regulations.”

9.2.4 Energy retailers’ hardship and disconnection policies

In New Zealand, the Government has issued a policy statement (through the Ministry of Economic Development, 2008b) on electricity governance, which requires the Electricity Commission to ensure that the terms and conditions of contracts between domestic consumers and electricity retailers (and where applicable, contracts between domestic consumers and electricity distributors) reflect the “reasonable expectations of consumers”. The policy requires the Electricity Commission to address a number of issues, including any arrangements for the benefit of low income domestic consumers.

The Electricity Commission website (2006) suggests that the most notable example of how it has responded to low income domestic consumers is by putting in place updated guidelines for energy retailers that enhances the process around disconnections for non-payment, including a range of requirements that retailers must meet before a disconnection can take place. The guidelines are intended to ensure:

- no consumer who meets the definition of vulnerable consumer, or who is dependent on electricity for critical medical support, is inappropriately disconnected for non-payment
- that minimal disconnections for non-payment occur, with standards for such disconnections
- all consumers are aware of the payment options and services offered by retailers and social agencies
- retailers have a process for identifying preferred contacts for consumers in the event of non-payment
- that consumers enter into the most appropriate contracts for their needs.

9.2.5 Prepayment meters

Approximately 18 percent of fuel poor households in Britain pay for electricity via prepayment meters and 12 percent pay for gas by this method (BERR, DEFRA, 2008, p18).

Boardman and Darby (2000, in Wright, 2004, p500) found that a high proportion of prepayment meter customers incorrectly believe they pay less for fuel than customers using other payment methods. However, pre-payment meter customers pay more for their energy than those on standard or direct credit payment plans, in order to cover ‘additional costs’ (BERR, DEFRA, 2008a, p18; House of Commons: Business Enterprise Committee, 2008, p54). The issue of whether these additional charges to pre-payment meter customers actually reflect additional administration costs is currently being investigated by OFGEM (House of Commons: Business and Enterprise Committee, 2008, p54).

The UK National Forum for Financial Inclusion (Transact) (2009) states:

“a consumer paying for both gas and electricity with a pre-payment meter (PPM) pays on average £215 more for their energy than someone using direct debit. You are up to three times more likely to use a PPM if you live in social housing, have a disability or are a single parent. People already in debt to energy suppliers can have up to 70% of their meter payments taken in arrears, leaving little to heat their homes.”

He Kainga Oranga/Housing and Health Research Programme (2008, p3) at the University of Otago, in its submission to the Ministry of Economic Development’s Market Design Review Paper, states:

“some overseas organisations suggest that many consumers using prepayment meters express a high level of satisfaction with them, and state that they would be reluctant to switch to a different payment plan. This may be due to the limited competition between prepayment meter plans, or to costs associated with switching. Others argue that low income people prefer the discretion and privacy that prepayment metering offers, rather than face negotiation with electricity companies, reconnection fees, and uncertainty about when they will be disconnected (Sharam, 2003). Recent qualitative data we have undertaken on older people with chronic illnesses suggests that prepayment meters can disguise disconnections, when they are voluntarily made as a budgeted measure. The overseas experience suggests that the use of smart metering has had the effect of ‘cherry-picking’ the most lucrative consumers, leaving low income consumers to face ‘social dumping’ onto more expensive prepayment pricing schemes (Graham 1994).”

9.3 Energy efficiency interventions

Energy efficiency interventions are commonly reported in the international literature. Interventions that are typically reported in this category include complete retrofits, improved ceiling and/or wall insulation, draught proofing, hot water cylinder wraps and double glazing for windows.

The review has found a scarcity of research-based sources supporting the link between the energy efficiency of the building envelope and household energy affordability. Wright (2008) suggests that residential energy use and the energy performance of the building envelope are very weakly linked, adding that “households have a stronger influence on energy use than does built form.”²⁰ It is important to note that energy efficiency interventions can ameliorate energy hardship through two different approaches. Improved energy performance of the house allows:

- the same level of energy service to be provided at reduced cost, and this cost reduction to be taken as economic savings
- a greater level of energy service to be provided at the same economic cost, potentially providing wider economic benefits for the household.

²⁰ Built form refers to the insulation level and immediate surroundings of a home, the type of dwelling (terrace, semi-detached house, bungalow, flat, etc), its geometry, internal layout, floor area, and construction (solid or cavity wall, timber frame, solid or suspended floor, etc).

However, a review of the Warm Front scheme in the UK, has found that “energy efficiency improvements may not be achieving the reductions in space heating fuel consumption that are theoretically assumed even after the effects of increased comfort have been taken into account” (Hong, Oreszczyn, and Ridley, 2006).

This research potentially highlights the need to develop a better understanding of how households make trade-offs between comfort and energy savings.

9.3.1 Insulation

Heat loss through the building envelope can be reduced by insulation, which can be either (Lloyd, Bishop & Callau, 2007, p7):

- *bulk insulation*, that works by resisting heat flow by conduction and convection, relying on the low thermal conductivity of insulation materials and pockets of trapped air. Performance is compromised if the material is squashed, if there are gaps around the material, or if the material absorbs moisture
- *reflective insulation*, that works by reducing radiant heat transfer, relying on highly reflective materials. Performance is compromised if the reflective surface is touching the opposite wall, or if dust builds up on the reflective surface reducing the reflective property.

The Healthy Housing Programme²¹, carried out in a sample of New Zealand state housing stock, involved extensive insulation, ventilation and heating upgrades, as well as addressing housing design issues, overcrowding and referrals to social and health services (Clinton, McDuff, Bullen, Kearns & Mahoney, 2005). Based on data for the period July 2003-June 2004, 96.1 percent of all households in the programme received insulation, ventilation and/or heating upgrades (Clinton & McDuff, et al 2005, p18). An evaluation of the programme noted that there had been a 37 percent fall in acute housing-related hospitalisations²² in the year following the intervention (Laing & Baker, unpublished).

Chapman, Howden-Chapman and O’Dea (2004) conducted a cost-benefit analysis of insulating homes, and found that compared with a control group those living in insulated homes:

- reported 19 percent less visits to the doctor during winter
- took 23 percent less days off school
- took 39 percent days off work
- and used 28 percent less energy to heat their homes.

In total the analysis demonstrated almost \$2.00 worth of benefit for every \$1 spent on insulation. Note that a further benefit not quantified in this cost benefit analysis is increased physical and emotional wellbeing associated with increased warmth and comfort.

In New Zealand, the Energy Efficiency and Conservation Authority (EECA) provides government grants for insulation and clean heating. The Warm Up New Zealand: Heat Smart programme launched on July 1, 2009 replaces previous schemes run by EECA since 1996. Warm Up New Zealand: Heat Smart is funded to retrofit 180,000 houses over four years to 2012. Warm Up New Zealand: Heat Smart provides a

²¹ The Healthy Housing Programme is a collaborative initiative involving Housing New Zealand Corporation, and Counties Manukau, Auckland, and Northland District Health Boards.

²² The evaluation of the Healthy Housing Programme identified a list of ‘potentially housing-related’ diseases: tuberculosis, gastroenteritis, ENT infections, rheumatic fever/heart disease, respiratory infections, chronic obstructive respiratory disease, asthma, cellulitis, meningococcal infection.

greater level of financial support to low income households and is open to all owners of houses in New Zealand including landlords. The level of financial support provided is summarised in Table 9 below.

Table 9: Summary of funding provided by Warm Up New Zealand: Heat Smart, as at July 1, 2009

House owner type		Financial assistance
All house owners		1/3 off the installed cost of funded insulation measures, up to \$1,300 (GST incl) \$500 (GST incl) off the installed cost of clean heating
Low income house owners ²³		60% off the installed cost of funded insulation measures \$1200 (GST incl) off the installed cost of clean heating
Landlords	Other tenants	1/3 off the installed cost of funded insulation measures, up to \$1,300 (GST incl) \$500 (GST incl) off the installed cost of clean heating
	Low income tenants ¹⁹	60% off the installed cost of funded insulation measures \$500 (GST incl) off the installed cost of clean heating

EECA also administers EnergyWise Clean Heat, funded through the Ministry for the Environment. EnergyWise Clean Heat provides grants to low income households in areas of poor air quality to replace older polluting heating appliances with clean heating alternatives. The Government provides 50 percent of the total cost and third parties (mostly councils) provide the remaining cost. The programme delivers on average around 700 retrofits per annum. It began in 2007-2008 and is funded to 2010-2011.

9.3.2 Energy efficient appliances

The *He Kainga Oranga*/Housing and Health Research Programme within Otago University carried out research that replaced unflued gas heaters and portable electric heaters with clean, efficient space heaters (Howden-Chapman, et al 2008). Howden-Chapman et al (2008, p6) report that “installing non-polluting, more effective home heating in the households of children with asthma in New Zealand did not significantly improve lung function but did lead to a reduction in symptoms of asthma, improved wellbeing, and fewer days off school”.

Sustainable Energy Ireland (2003, p22) found that there is a lack of awareness of which heating systems were energy efficient, and noted that “the difference between what the public believes to be an adequate heating system and what actually is adequate demonstrates one key cause of market failure, the ‘information gap’”. This indicates that education may be a useful intervention in terms of raising awareness of

²³ Community Services card holders, or SuperGold Card holders with Community Services Card eligibility.

the issue of energy affordability, and potentially ensuring New Zealand households have sufficient information to make informed decisions when replacing space heating appliances.

In a bid to curb residential energy consumption, many countries have introduced energy efficiency standards on newly manufactured household appliances. For example, EECA notes on its website that New Zealand has worked with the Australian Government to establish and maintain Minimum Energy Performance Standards (MEPS) on appliances and equipment. Almost all of New Zealand's standards are, or soon will be, joint standards with Australia.

However, Young (2007) notes that what may be more important for realising household energy demand savings (in response to technological improvements) is the rate at which households replace various appliances. Households with higher levels of disposable income are more likely than lower income households to replace their appliances earlier (Young, 2007; Schipper and Hawk, 1991). In a Canadian study, Young (2007) notes that all appliances except refrigerators appear to be sensitive to income. The study notes that, if lower income households are holding on to older appliances (namely clothes washers, in the case of this study) due to financial constraints there may be scope for policies that provide financial incentives for the replacement of these appliances with more energy efficient models, leading to lower residential energy use.

9.3.3 Air tightness

Shen (2004, p86), in a study of low income households in the lower South Island, found that "houses with aluminium window frames showed improved temperatures of 1.7°C higher than those with wood frames, presumably because there was less air infiltration around the windows and the houses were relatively new".

9.3.4 Prioritisation of energy efficiency interventions

Lloyd, Bishop and Callau (2007) carried out research exploring the impact of energy efficiency retrofits on indoor temperatures, from which they were able to produce a list of energy efficiency upgrades in order of priority²⁴:

- insulate the ceiling
- insulate the floor
- install a low emissions wood burner or pellet fire
- install a heat pump that will replace electric heaters used elsewhere in the house
- improve air-tightness
- insulate walls
- install double glazing (or drapes).

9.3.5 Energy advice lines

The UK Energy Saving Trust (an independent not-for-profit organisation) currently operates a network of 21 Energy Saving Trust advice centres across the UK, a service it began in 1996. The centres (Energy Saving Trust UK, website):

- are accessed via a freephone number

²⁴ Note that the following list is based on modelling work carried out based on HNZC homes in the lower South Island. The order of the list is likely to be dependent on a number of factors, such as the floor area of the house and the window:wall ratio.

- provide free impartial information on home energy efficiency to assist people to improve the energy performance of their house
- are regional, so have a good knowledge of their area, the characteristics of local housing stock and the local installation market so they can recommend suitably qualified interventions and tradespeople
- advise on any grants and offers available to assist house owners' measures.

New Zealand has only recently adopted energy advice lines. The Energy Efficiency Community Network operates a national Home Energy Advice Centre (HEAC) with offices in Auckland, Wellington and Christchurch. The HEAC provides a not-for-profit, independent and impartial advice service for all New Zealanders, funded by central and local government, and other community agencies. The HEAC (nd):

- is accessed via a freephone number
- provides written advice and information
- provides referrals to government supported schemes and energy efficiency suppliers and services
- provides home visits/assessments (home energy checks).

9.4 Attitudes and behaviours

9.4.1 Smart meters

Internationally, the status of smart metering implementation programmes ranges from conceptualisation, through cost-benefit analyses and trials, to completed implementation. Beardmore, Riley and Weir (2008) note that jurisdictions that have mandated a mass market roll out of smart metering include most Australian states, numerous American and Canadian states, Italy, Ireland, and Sweden. The UK Government in its UK Low Carbon Transition Plan, released in July 2009, states "the Government has committed to mandating smart meters and has set out an indicative timetable for getting smart metering to all homes by the end of 2020".

A report recently commissioned by the Parliamentary Commissioner for the Environment (Concept Consulting Group Limited, 2008) notes that, despite the small number of smart meters currently installed in New Zealand, there appears to be an intention amongst the majority of electricity market participants to move towards smart metering over the next five years. Concern is raised in the report about the level of functionality of smart meters that are likely to be rolled out and their ability to influence consumer behaviour.

A literature review commissioned by DEFRA (Darby, 2006) found that a growing number of overseas studies suggest that direct feedback, if appropriately implemented, can engender behavioural changes in consumers in the form of more efficient energy consumption patterns (eg switching off unused appliances and lights, turning down thermostats etc). Stevenson and Le Prou (2008) note that the enabler for demand response isn't confined solely to metering arrangements, but that it is also a function of publicity and information.

A report by the OECD (2001) notes that metering equipment remains prohibitively expensive for many small and residential consumers.

9.4.2 Tariffs

Research undertaken by the Ontario Energy Board in Canada (2007) to test the reactions and impacts of different time-sensitive price structures on consumer behaviour suggested that, on average, participants in the study paid lower bills under a time-of-use pricing structure as compared with the existing regulated price plan in Ontario.

Wolak (2007) reports that compared with control households those on a 'critical peak pricing plan' consumed, on average, 12 percent less electricity during peak hours. However, there was no difference in total average consumption between these two groups.

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