STUDY REPORT

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National Impacts of the Widespread Adoption of Heat Pumps in New Zealand

NR Buckett

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Preface

This report examines the wholesale swing toward heat pump technologies as the way New Zealanders heat their homes changes, and the possible effects of such a shift on New Zealand as a whole.

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Cheryl and Stan Redit, Cozycool, Redway, New Zealand
Robert Tromop, EECA
Marion Pahalawatta, EECA.

Note

This report is intended for government organisations, policymakers, and those with an interest in sustainability and healthy housing.

NATIONAL IMPACTS OF THE WIDESPREAD ADOPTION OF HEAT PUMPS IN NEW ZEALAND

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Abstract

The heat pump air conditioner market in New Zealand has experienced rapid growth over the past few years, with the number of sales more than trebling between 2001 and 2006. Promotion by local and central government and strong industry campaigns have educated the consumer on the potentially high energy efficiency of heat pumps for domestic heating. This report looks at the ramifications of such rapid growth on New Zealand, and the potential consequences of the shift in heating types on household behaviour, infrastructure and workforce. Changes in energy use patterns, heating and cooling behaviours have been witnessed in homes where heat pumps have been subsidised to replace open fires and older woodburners. This has ramifications for the electricity loadings for heating, as well as hot water loadings where wetback hot water systems are removed. The pursuit of comfort due to the ability to achieve higher temperatures, rather than savings due to higher efficiency, is being recognised in New Zealand's consumer society. Labour shortages for heating, ventilation and air conditioning mechanics exist, and poor quality installation and incorrect sizing of heat pump units have been witnessed in New Zealand. Currently there are no educational requirements aside from electrical certificates being mandatory for heat pump installers.

Keywords

Heat pumps, New Zealand, air conditioning, energy efficiency, electricity, home heating, comfort.

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1. INTRODUCTION

Air source heat pumps for residential space heating have become increasingly popular in New Zealand, with rapid uptake over the last few years. The publicity surrounding their potentially high levels of efficiency has come from the electricity and heat pump industries, local and national government entities, electricity providers, and charitable organisations, amongst others. With the increasing emphasis on improving air quality in urban centres around New Zealand, and the need for a reduction in carbon emissions in light of New Zealand's commitments to the Kyoto Protocol, heat pumps appear to be a solution.

With their high average efficiencies there is potential for the widespread installation of heat pumps to lead to a change in the heating methods and behaviours of New Zealanders, and to have both positive and negative spin-offs on energy use and supply, and people's health and well-being.

This report investigates the impact of heat pumps on New Zealand to date, concentrating on the domestic sector, and investigates what might happen in the future should current trends continue unabated.

2. OVERVIEW

The popularity of heat pumps for domestic space heating has grown over the past few years, with some estimating that the number of heat pumps sold at least trebled between 2001 and 2006 (Energywise 2006). The rapid growth in the numbers of heat pumps is likely to have widespread impacts on New Zealand. However, it appears that these impacts have not yet been fully considered. This report seeks to explore the likely impacts and provide an indication of what New Zealand may need to cope with the shift.

New Zealand is experiencing a shift in attitude toward the environment, climate change, and how we are living. Amongst the push of the Kyoto Protocol, air quality concerns in many regions, the increase in electricity demand and peak loadings, and the recognition that New Zealand's houses are amongst the coldest in the developed world, the focus has turned to finding part of the solution in the way New Zealanders are heating their homes (MED 2006a).

Heat pumps have been and continue to be strongly promoted by national and local governing bodies, charitable organisations, manufacturers, and those who have invested in the technology. Government and industry market drivers are encouraging New Zealand households to abandon the more traditional forms of heating, such as open fires, the almost extinct coal range, solid fuel burners, and gas heaters in favour of electricity-fuelled heat pumps with high average efficiencies and no direct effects on local air quality. The indirect effects are now beginning to be addressed with the relatively recent shift back toward renewable electricity, with the opening of the Te Rere Hau Wind Farm in September 2006, and the abandonment of plans to recommission the Marsden B power station near Whangarei (*New Zealand Herald* 2007), although energy security is placed as a higher priority than renewable electricity (MED 2006b).

However, the HEEP (Household Energy End-Use Project) study of 400 houses throughout New Zealand has shown that a far higher proportion of New Zealand's home heating comes from solid fuel burners (Isaacs et al 2005) than had previously been anticipated. As yet there is no firm data or estimates to indicate how many woodburners are being replaced each year; however the Clean Heat project has replaced 4,800 solid fuel burners since its beginnings in the Canterbury region. The act of encouraging the replacement of large numbers of solid fuel burners with heat pumps is likely to have detrimental effects on New Zealand's already strained electricity networks and heavily loaded power stations, especially as dry years take their toll on the production levels of hydro-electricity. This has the potential to increase pollution from the generation of electricity, as supplementary power stations utilise the combustion of polluting fossil fuels to cope with demand and assist with energy security. Whether heat pumps have the ability to satisfactorily replace other forms of space heating in all situations, and whether they actually reduce carbon emissions, is questionable when over a quarter of New Zealand's electricity was generated using fossil fuels in 2004 (Dang and Cowie 2006).

The performance and efficiency of heat pumps is dependent upon a set of factors. Incorrect sizing, incorrect refrigerant charge, poor installation, incorrect positioning and cold weather all have a detrimental affect on the performance and efficiency of the heat pump. The problem of incorrect or poor quality installation is widespread in other countries (EPA 2005), and has been witnessed in New Zealand (Consumers Institute 2005). In New Zealand there are currently no specific educational requirements for heat pump installers aside from sufficient electrical qualifications. Consumer laws give some protection over the effectiveness of the installed product providing they are professionally installed.

The performance of heat pumps is highest at warmer temperatures where they do not have to stop producing heat to defrost the exterior coil. This is usually at temperatures over 7°C, indicating the appliances are best used in warmer climates. The performance of the heat pump drops rapidly at temperatures below approximately 7°C, and while the efficiency is still higher than other forms of heating, the air source heat pumps may produce insufficient heat to maintain a satisfactory comfort level for occupants if the system is undersized.

Heat pumps, with thermostats and timer controls, have the ability to climate control indoor environments. As a result, it has been shown that during the second year of installation, occupants of homes with heat pumps are likely to increase the thermostat temperature on their heat pump (Fyfe 2005). This indicates that heat pumps may be increasing the comfort expectations of people with the technology, and as the appliances become more common, it is likely that more homes will be heated to higher levels and possibly for longer periods of time. Therefore the real benefits of the high efficiencies of heat pumps may not lie in energy savings, rather in comfort and the benefits that entails.

Increased comfort expectations are also likely to affect energy consumption in summer. The new accessibility of cooling from the reverse cycle of most heat pumps means that many are likely to begin air conditioning in summer. Should the same pattern of increasing comfort expectations occur with cooling as well as heating, the comfort bands of many New Zealanders are likely to narrow, leading to higher amounts of summer cooling, and an additional energy peak from the residential sector to add to the existing summer peak currently assumed to be from predominantly commercial sources.

New Zealand's electricity is a form of energy that is often perceived to be reliable and clean. However, in reality it is vulnerable to weather extremes, which are forecast to increase in numbers and severity with climate change (MfE 2001), and over a quarter of which was generated using non-renewable fuels in 2004 (Dang and Cowie 2006).

As recently as 1998, major brown-outs affected Auckland, New Zealand's most populous city and a major centre of commerce, leaving commercial and retail buildings without air conditioning in the height of summer through to early autumn. In mid-2006 a black-out was caused by a broken feeder cable to an Auckland power station, and a major snowfall event causing the downing of lines over a large part of the South Island for up to three weeks. In addition there have been constant warnings that New Zealand is near its maximum capacity for energy generation (Leyland 2004, Leyland and Mountain 2002, Whitney and Trolove 2006). Consumers appear to be expecting increasing levels of comfort each year (Fyfe 2005, Wu and Pett 2006), leading to a growth in domestic air conditioning. In all of the winter events, people with only electric heating, such as heat pumps, have been left in the cold. On this basis it is questionable whether it is wise to continue to encourage New Zealanders to invest in one technology that can only use a source of energy that is vulnerable at times of greatest need. Even with the government's renewed focus upon renewable energy and security of supply, rectifying the current issues will take time and money.

3. CURRENT STATE OF HEATING IN NEW ZEALAND

Currently around 40% of New Zealand's homes use a solid fuel burner as their main source of heating (Figure 1). 30% of the homes in the HEEP study used some form of electric heater as the main heater. 24% of New Zealand homes used portable electric heaters, 3% used nightstore heaters, and only 1% used heat pumps.

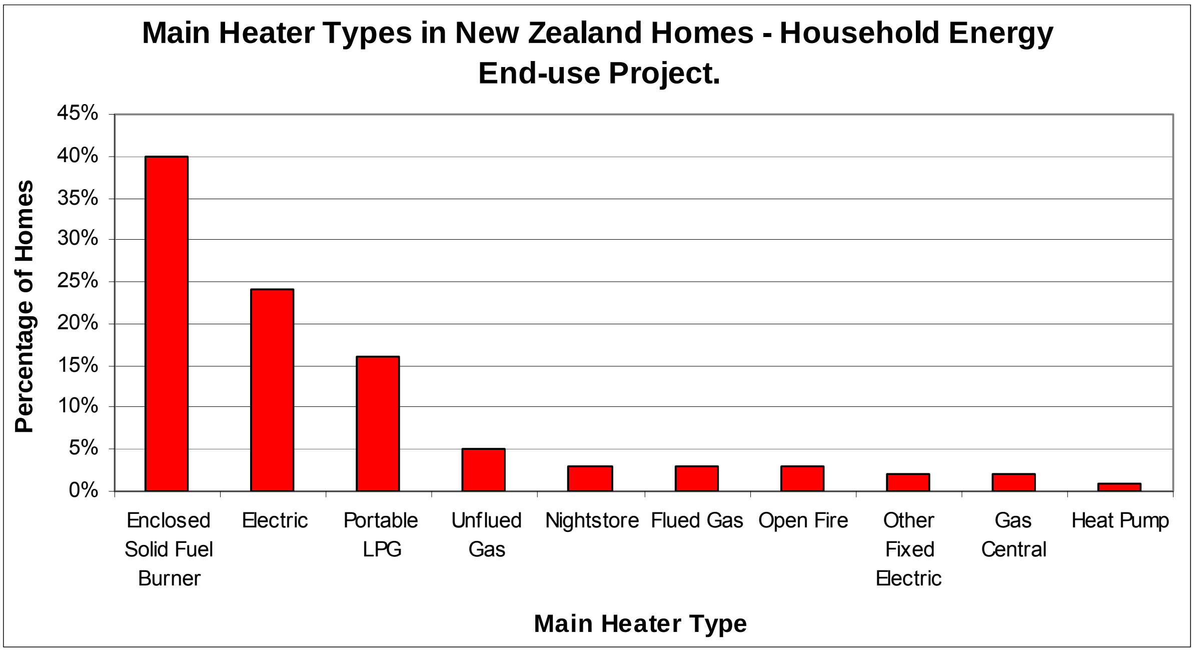

Figure 1: Main heater types in New Zealand homes as found in the HEEP project (BRANZ 2007)

It is worth noting that HEEP's monitoring period was stretched over 10 years, ending around May 2005. Around 100 houses in selected regions were monitored each year for the last three years, meaning that the figures obtained from those regions were representative at the time. However, the popularity of heat pumps is likely to differ from region to region, and as a result the number of heat pumps installed or being installed may have differed from the national average.

The relatively recent mainstreaming of the technology probably led to the proportion of heat pumps in HEEP being lower than what was found in the *2005 New Zealand Housing Condition Survey* (Clark et al 2005 – see Section 5.1.1).

4. WHAT IS A HEAT PUMP?

In the New Zealand context, a "heat pump" generally refers to an air source heat pump, also known as a reverse cycle air conditioner. These are electrical appliances which pull warmth out of the air outside and move it into a space, or vice versa when on reverse cycle. In heating mode, refrigerant moves through the outside coils of the appliance, where it evaporates into a gas. The heat from the refrigerant is transferred by the indoor coils as it condenses back into a liquid. The opposite happens when the heat pump is being used as an air conditioner.

4.1 Heat pump efficiency

The COP, or Coefficient of Performance, is the ratio of output versus input; for example, a heat pump running at a COP of 3 will produce heat energy of three times the energy put in, or 300% (also see Appendix 1). An electric radiant heater, for example, is assumed to have an efficiency of 100% as it can only produce as much heat as the energy put in.

Heat pumps are currently the only common form of space heating with a COP of more than 1, and are therefore the most efficient form of space heating on the open market in New Zealand at this time. However, the COP of the appliance ignores transmission, distribution and generation efficiencies.

As can be seen in Figure 2, the heat output of a heat pump decreases as outside air temperatures decrease until they reach a point where they must shut down completely, in this case at around 15°C below zero. Generally intermittent defrosting is required at or below outside temperatures of +7°C, except for in the driest of climates (Forsén 2005), since moisture in the air condensates on exterior coils and freezes disrupting the heat flow. This indicates that heat pumps best serve for heating in warmer areas, where they are likely to be more efficient. The downturn of this is that the warmer areas generally require less heating energy on average. However, a tailoring of the technology to the specific climatic requirements could provide equal, if not more, efficient heating for cold regions.

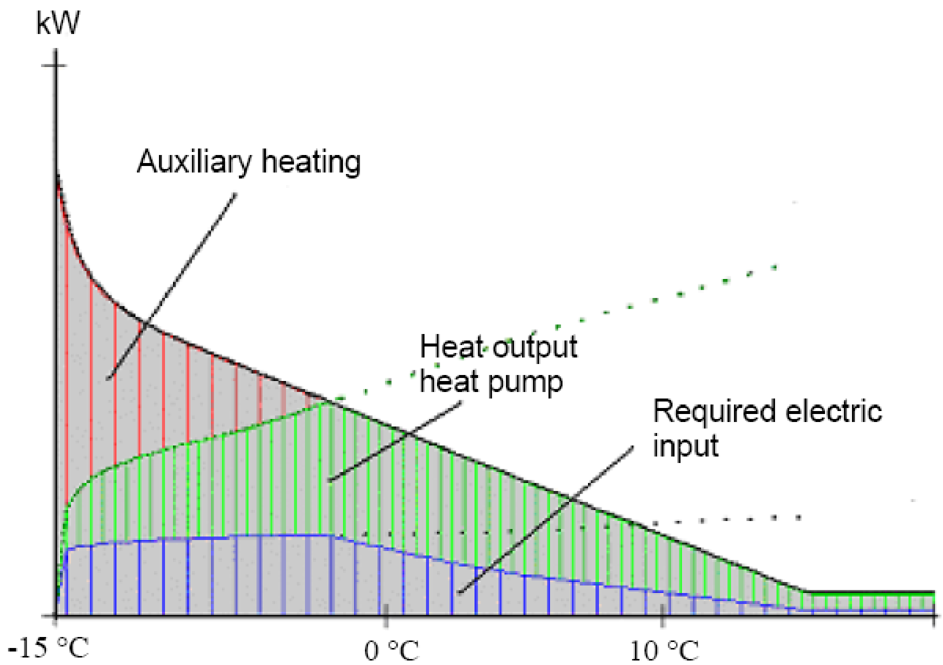

Figure 2: General characteristics of an air source heat pump (Forsén 2005)

An efficient alternative for very cold regions is a ground source heat pump (these work by retrieving heat from below the surface of the earth where seasonal temperature variation is reduced or eliminated depending on depth – ground temperature becomes more constant the deeper one goes). It is possible to have the temperature of the refrigerant maintained at well above +7°C year round, largely eliminating the need for heat pumps to defrost. Ground loops filled with a mixture of water and anti-freeze are installed into the ground. The heat from the liquid in the coils is transferred in a heat exchanger into the refrigerant, which is then compressed to increase the temperature of the refrigerant. The heat is then usually transferred into a hot water cylinder. The hot water is then transferred into the heating distribution system, usually radiators, underfloor heating, and other heating methods utilising hot water.

Ground source heat pumps tend to be more expensive than air source heat pumps (EERE 2005), and the extra cost may not be justified given the relatively low space heating demand, and the relatively mild winters in most parts of New Zealand. Ground source heat pumps are commonly used in very cold climates, like parts of North America and Europe where the air temperatures may be below freezing for weeks or months, and their higher cost can be offset against high energy consumption.

A New Zealand study has found that the carbon dioxide (CO_2) emissions of heat pumps are higher for heating than pellet fires (Housing and Health Research Programme 2005). As the outdoor temperatures fall, the COP of a heat pump decreases and less heat is delivered with the same amount of electricity being consumed. Therefore more CO_2 emissions are produced at lower temperatures than at higher temperatures as more power is required to maintain a certain temperature. It was found that the CO_2 emissions for one model of heat pump heating a room to 21ºC rose 24% when the outdoor temperature was reduced from 10ºC to -10ºC.

Overseas, the overall performance and efficiencies of heat pumps has also been brought into question. Field research in America has shown that the performance and efficiencies of a heat pump may be below expectations due to laboratory conditions during tests. Variables such as climate, occupant behaviour and the way heat pumps are used and controlled all affect their efficiency and performance (Lubiner, Andrews and Baylon 2005). As with most other things, a heat pump is only as energy efficient as those using it allow. With current consumer behaviour and the ability of heat pumps to climate control homes, there is the potential for comfort bands to narrow, as has been witnessed in the USA, and this is a trend which is expected to further develop in the UK (Wu and Pett 2006).

4.2 Heat pumps and extreme weather

Extreme weather events and very cold weather are a heat pump's downfall. Many heat pumps are unable to continue extracting warmth out of the air when their coils ice up, using additional energy to defrost if they have a defrost heating mode. At this point they may simply become a convection heater with an element, and their efficiency could drop to that of an electric heater – 100%. Some stop working entirely as the heat pump removes ice from its coil (Housing and Health Research Programme 2005). The COP also means that their efficiency decreases the cooler the air outside becomes, with the highest COP generally sitting around 14ºC exterior air temperature, although this can vary slightly with make and model (see Section 4.1).

The Consumer Magazine (Consumers Institute 2006) reported that the efficiency of heat pumps is reduced where outside air temperatures regularly fall to below 10ºC. Half of the participants in the Community Energy Action Charitable Trust (CEA) heat pump survey were also of the opinion that their heat pumps did not work as well on cold winter days (Fyfe 2005).

Few of the sources promoting heat pumps as a heating solution advertised the fact that the COP of heat pumps drops with the fall in temperature and difference in temperature between inside and outside (ΔT), or that the greater efficiency of heat pumps will save money only if you heat the same rooms to a similar temperatures and time schedules as before the installation of the heat pump. Even a heat pump with 300% efficiency at 7ºC exterior temperature will cost the same to heat a room previously heated to the same temperature with a heater with the same wattage from 1 pm to 9 pm, for example, if the heat pump is on constantly in winter, as per the recommendations of some installers (Walker 2004, Fyfe 2005). The heat pump will use more electricity if the temperature averages below 7ºC due to the reduction in efficiency in accordance with the COP. EECA's *Choosing a Smart Heat Pump or Air Conditioner* guide mentions that some heat pumps perform poorly at cooler temperatures, and recommended discussion with retailers should temperatures drop to below 2ºC on a regular basis where one is to be installed (EECA 2006b). This puts into question the reliability and suitability of such a form of heating in areas of New Zealand where prolonged cold periods are experienced, and where the supply of electricity is prone to disruption by unseasonable weather patterns.

While heat pumps are entirely reliant on electricity in order to operate, most of the other 'clean heat' registered technologies are also reliant on electricity and therefore vulnerable to becoming unavailable in times of electricity shortages or power cuts. Nightstore heaters are also entirely reliant on electricity to operate. They are able to store a day's worth of heat. However, the fans to distribute the heat do not operate during power outages and therefore are incapable of heating large areas. Many of the gas heaters require electricity for ignition, the timer or for a fan. Pellet fires also must have electricity at all times during operation,[1] although the draw of electricity is so small battery back-up could be used. The only registered heat technologies that are able to operate without electricity are diesel fires (although these often have electric fans and controls), woodburners, and fully mechanical gas or LPG heaters. The emphasis on forms of heating reliant upon electricity has the potential to unwittingly create total reliance on the national grid, typically the sole source of electricity for New Zealand households. This could pose a particular problem for remote areas during cold storms, as alternative means are required for heating and cooking. While the likelihood of this happening in the warmer regions is remote, the cooler regions should perhaps be encouraged to continue to use solid fuel heating sources and retain some independence from the national electricity grid for space heating.

5. LITERATURE REVIEW

5.1 Uptake of heat pumps

5.1.1 New Zealand

There is currently strong growth in the use of heat pumps for space heating (MfE 2005) in New Zealand's approximately 1.6 million houses. Sales of heat pumps in New Zealand trebled in the five years (Energywise 2006) from 2001 to 2006. Some installers are currently unable to keep up with demand,[2] a situation exacerbated by the recognised skill shortage in the industry (DOL 2006).

The HEEP project is a nationally representative study on the end use of all fuels used in 400 New Zealand houses in the 10 years from 1995 to 2005. The study did not report the number of heat pumps in the surveyed houses separately, as the technology was not common enough to warrant a separate mention, with only six out of the 400 houses (or 1.5%) possessing the technology in the monitoring period for 10 years up to 2005.[3]

In the *2005 House Condition Survey*, the numbers of houses with heat pumps rose from none in the sample in 1999 to 6% of the sample in 2005 (Clark et al 2005). It was estimated that there were heat pumps in 13% of the 57% of New Zealand houses using

[1] Personal communication with Jessica Harris of Harris Flame Technology.

[2] Personal communication with Cheryl Redit, CozyCool, Porirua, New Zealand.

[3] Personal communication with Lisa French, BRANZ Ltd, Judgeford, New Zealand.

mainly electricity to heat living areas in New Zealand (Wilton 2005). This works out to be 7.5% of the total number of houses in New Zealand, or approximately 120,000 houses, up from virtually none less than a decade ago.

Heat pump sales figures are currently held by EECA and perhaps other government agencies, but are not publicly available due to confidentiality and market sensitivity reasons. The only information on heat pumps that EECA provided for this report was on the category of single phase air conditioners, which included sales in all sectors (see Table 1 and Figure 3). This data shows that the number sold in 2006 was nearly six times the number sold in 2000.

Table 1: Single phase air conditioner sales in New Zealand by year (EECA 2006a)[4]

Single phase air conditioner sales							
Year to March	2000	2001	2002	2003	2004	2005	2006
No. units sold	12294	14070	19194	22234	36127	54078	72002
Percentage growth		14%	36%	16%	62%	50%	33%

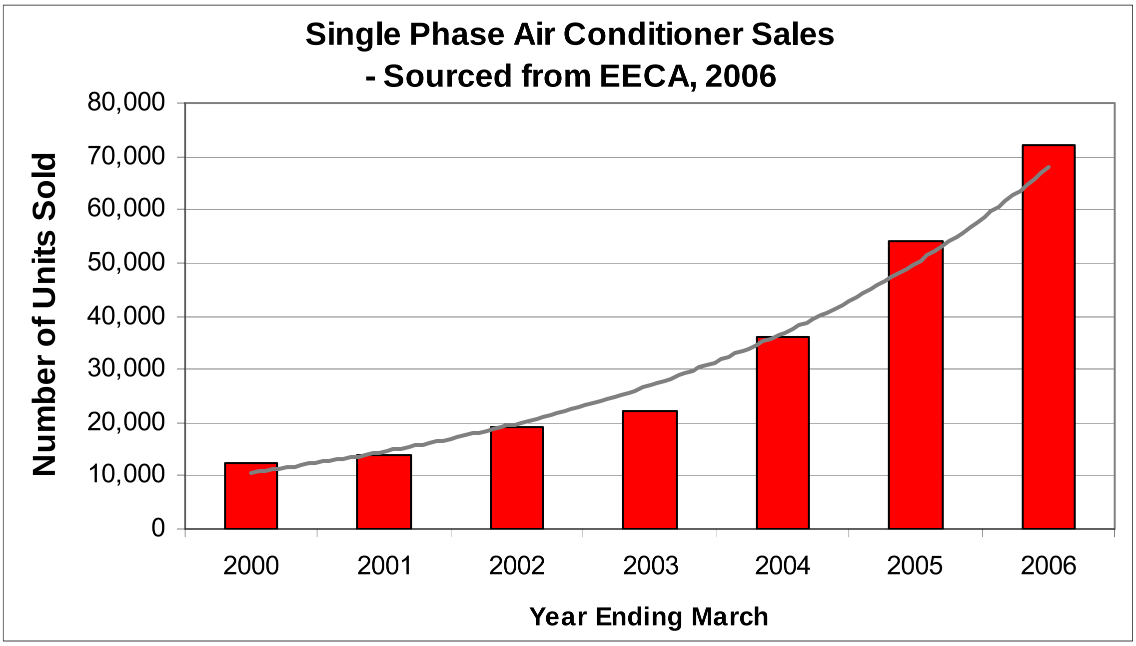

Figure 3: Annual single phase air conditioner sales in New Zealand from 2000 to 2006 (EECA 2006a)[4]

The growth in the market appears to be slowing from a peak of 62% growth in the year to March 2004 to 33% in the year to March 2006. The absolute growth in numbers of single phase air conditioners sold in the year ending in March 2006 was more than the total sales in the year to March 2001 by around 18,000 units.

According to EECA, most of the single phase air conditioner units have a reverse cycle function[5] and are therefore heat pumps. How many of these are installed into domestic situations is unknown, but are more likely to be utilised in domestic and small-scale commercial circumstances (Woodward et al 2001). Overall, this data shows that around 230,000 single phase air conditioners were sold in New Zealand between March 2000 and March 2006.

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[4] Sales figures for the year ending March 2006 were confirmed by Marion Pahalawatta, EECA, 30 March 2007.

[5] Personal communication with Marion Pahalawatta, October 2006.

5.1.2 The big wide world

Heat pump technology has been available in some parts of Europe since the 1970s (Forsén 2005). In Austria records of space heating heat pumps began in 1975, and installations peaked in 1982 at about 3,500 per year. There are currently approximately 120,000 heat pumps for water heating and around 40,000 for space heating, out of approximately 3 million Austrian households. The majority (52%) of space heating heat pumps in Austria are ground source heat pumps rather than air source heat pumps (22%) (IEA Heat Pump Centre 2006). Sales of heat pumps in Austria have grown slowly since 2000 (IEA Heat Pump Centre 2006) as the market is mature. In Norway approximately 9% of houses had an air source heat pump unit in 2006 (200,000 units out of approximately 2.2 million homes) (Norwegian Heat Pump Association 2007, Statistics Norway 2006). Sales in Norway have declined recently (IEA Heat Pump Centre 2006, EHPA 2005a, EHPA 2005b) as the heat pump market is mature, with heat pumps sold to replace existing units or for new dwellings.

Australia has had a high uptake of heat pumps and air conditioners since 2000, climbing to about 500,000 units per year in 2002 and 2003 (NAEEEC 2004). Heat pumps in Australia are used for both heating and cooling in almost all climate zones, with the majority of heating taking place in the cooler winter climates of Canberra, Melbourne and Hobart (EPA 2005). The percentages of households with air conditioners vary widely between states in Australia, from a low of 22% in Tasmania to 95% in the Northern Territory, reflecting climatic differences, fuel accessibility and cost differences (EPA 2005).

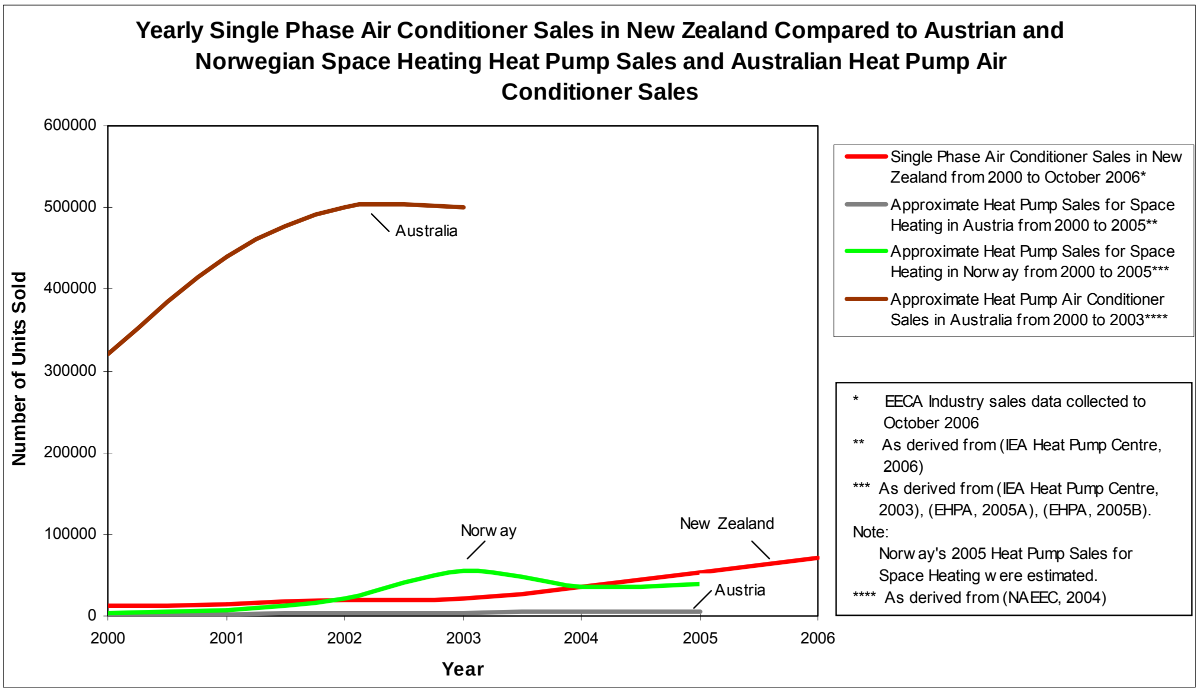

Figure 4: Single phase air conditioner sales in New Zealand from March 2000 to March 2006 (see Figure 3) plotted against heat pump space heating sales in Austria and Norway from 2000 to 2003 and heat pump air conditioner sales in Australia from 2000 to 2003. As derived from (IEA Heat Pump Centre 2006), (EHPA, 2005b), (EHPA 2005a), (EPA 2005), (EECA 2006)

5.2 Market Drivers

5.2.1 New Zealand

The influencing factors behind this widespread adoption of heat pumps in New Zealand are many and varied. Of the more significant factors, market drivers have been used to encourage New Zealand society into considering different home heating methods than they may have in previous decades. A New Zealand report has suggested that media and promotions by government bodies and power companies are highly effective market drivers (MfE 2005). While certain segments of society are attracted to new technologies, some are harder to persuade. It has been recognised that multiple sources of publicity are effective in targeting more households that are more resistant to change (MfE 2005).

The result of the promotion and marketing done to promote heat pumps as a 'clean heat' technology seems to have made sizeable inroads into transforming the home heating market and the influence of the activities appears to be growing. It was shown that the level of public awareness of Environment Canterbury's Clean Heat project was 72% of those surveyed (Opinions Market Research Ltd 2005). 59% of those surveyed were aware of the advertising and information from the project.

Higher promotion of heat pumps over rival 'clean heat' technologies is likely to have contributed to the trend which now sees more of those accessing government funding opting to install heat pumps rather than other clean heat technologies. From 7.2% of open fires being replaced with heat pumps in the Christchurch 'Helping Hands' incentives scheme (Wilton 2001), to 62% in the Clean Heat project (ECAN 2006b), the popularity of heat pumps as a heating system appears to be growing amongst New Zealand consumers.

The Department of Labour has acknowledged a "genuine shortage" of skilled heating, ventilation, refrigeration, and air conditioning engineers, with Employer Survey Indicators showing a fill rate of 48% for advertised positions in 2005 (DOL 2006). This shortage has the potential to lower the quality of the installations.

There have been cases reported in New Zealand where heat pumps have been installed that are insufficient for the job, and are likely to have either been installed incorrectly, or the wrong size has been installed even by those claiming to specialise in the installation of heat pumps (Consumers Institute 2005, Fyfe 2005).

However, there are many 'off-the-shelf' products available which should be installed by suitably qualified individuals, or at least an electrician. However, it is possible that the do-it-yourself nature of many New Zealand homeowners may mean that some are installed illegally.

An appetite amongst many consumers for the lowest possible price for the technology encourages the introduction of inferior products and installations, and means those with the least money to spend on the technology may end up with poor product and installation quality. The former can be combated with regulation such as Minimum Energy Performance Standards (MEPS), however the latter is harder to control.

Another aspect to poor installation is noise pollution that may arise from misplaced exterior units. If situated close to other houses, apartments or fence lines, the fans in the outdoor units can be relatively loud and cause discomfort to neighbours. Several regional and city councils have observed this happening, and the Dunedin City Council's Environmental Health Section has produced a pamphlet illustrating how best to install heat pumps in order to prevent "noise nuisance" (Dunedin City Council 2006). As the number of heat pumps in New Zealand homes continues to grow, it seems inevitable that noise disturbances from heat pump units are also likely to rise.

5.2.2 The big wide world

Internationally, subsidies and incentives have been used by many countries to encourage the uptake of heat pump technology in domestic situations. Subsidies, rebates and/or incentives for space heating heat pumps and/or their installation exist in many countries other than New Zealand, some of which include Australia (Roads and

Traffic Authority 2007), Germany, Sweden, the Czech Republic, France, the UK (Forsén 2005), and the USA (DSIRE 2005).

It has been found that there are negative effects associated with the subsidising of heat pumps. As found in Sweden, subsidies have the potential to be a disadvantage where they overstress the existing suppliers and installers (Forsén 2005). This has the potential to lead to lower installation quality or the arrival of unqualified opportunists taking advantage of the publicity to make money from the overflow of work, or by offering cheaper products and service (MfE 2005).

According to a research study funded by EnergyStar in the USA, poor installation can lower heat pump performance by up to 50%. A reduction in efficiency of this size has the potential to remove much of the advantage of installing the technology over conventional electric heaters. In the USA it is estimated that over half of all air conditioners and heat pumps installed into domestic circumstances are adversely affected by incorrect installation, with common problems being incorrect sizing, placement and refrigerant levels (EPA 2005).

5.3 Regulation and governance

Regulation is a powerful tool that can be used by government authorities to modify markets through imposing restrictions or bans. In New Zealand a variety of legislation exists to protect the consumer from ill-performing, poor quality products, and the environment from less efficient models and potentially potent greenhouse gases used as refrigerants in the units. Installers are required to possess certain electrical qualifications. However, specific training in heating, ventilation and air conditioning is not strictly required.

5.3.1 Minimum Energy Performance Standards (MEPS)

In 2002 the initial stage of MEPS was introduced to improve the efficiency and performance of air conditioners and heat pumps sold in New Zealand. The mandatory requirements for air conditioners including the cooling cycle of heat pumps (note that heating efficiency is not included) were introduced in October 2004 (see Table 2). As technology progressively becomes more efficient as the market reacts to the legislation, the minimum level of efficiency is raised in turn. MEPS levels for air conditioners increased in April 2006, and will increase in October 2007 and again in October 2008.

Table 2: Minimum Energy Performance Standards (MEPS) Minimum EER Requirements for single phase reverse cycle air cooled condenser air conditioners

Configuration	Rated Cooling Capacity (kW)	Minimum EER 1/10/2001	Minimum EER 1/10/2004	Minimum EER 1/04/2006	Minimum EER 1/10/2007	Minimum EER 1/10/2008
Non-ducted unitary (window/wall)	<7.5	n/a	2.3	2.75^	2.75	2.84[a]
	7.5 to <10	n/a	2.3	2.3	2.75	2.84[a]
	10.0 to 18.9*	n/a	2.3	2.3	2.75	2.75
Non-ducted split	<4	n/a	2.3	3.05^	3.05	3.33[a]
	4 to <7.5	n/a	2.3	2.75^	2.75	2.93[a]
	7.5 to <10	n/a	2.3	2.3	2.75	2.93[a]
	10.0 to 18.9*	n/a	2.3	2.3	2.75	2.75
Ducted (split and unitary	0 to <10	n/a	2.3	2.3	2.5	2.5
	10.0 to 18.9*	n/a	2.3	2.3	2.5	2.75

*For single phase product over 18.9 kW cooling capacity, the relevant 3 phase MEPS level for the rated cooling capacity is applicable from October 2008.

^ Increased MEPS levels for 1 April 2006 apply to any product marketed for household use. Products which are purely commercial are subjected to the 2006 MEPS levels indicated apply from 1 October 2007. MEPS for 2007 and 2008 apply to all products, irrespective of use.

[a] These MEPS levels are subject to confirmation by an amendment to this standard during 2006.

Products must conform to MEPS legislation in order to be allowed to be sold in New Zealand. The effect of this legislation has removed some less efficient models from the New Zealand marketplace. This may remove some cheaper models, increasing the cost of heat pumps. However, the overall costs including running costs should be lower.

5.3.2 Clean air policies

Thirty air sheds around New Zealand are required to minimise their breaches of national air quality standard fine particulate (PM10) levels under the National Environmental Standards Legislation, which takes force in 2013. All air sheds are required to steadily improve their air quality, otherwise no resource consents will be granted for the discharge of smoke or soot if breaches continue to take place. This has the potential to restrict industrial activities, and stop consents for particulate-emitting appliances, such as woodburners, from being issued.

In response to the clean air requirements, Environment Canterbury started the Clean Heat project, which removes open fires and older, polluting solid fuel burners and replaces them with subsidised clean solid fuel burners, heat pumps, or other approved clean heaters. Similar projects are already in place in the Tasman district and under consideration in many other districts.

The LineTrust Ecoheater program in Canterbury subsidises the installation of heat pumps into houses which use electricity as the main fuel to heat their homes, and only allows heat pumps to replace woodburners in Timaru, which has major air pollution problems caused by wood burners (Ecoheater 2006).

The Clean Heat project goes further to reduce the air pollution at a national level, rather than just a local level, by improving the energy efficiency of the homes in the project rather than just replacing the heaters. The majority of houses have insulation, typically ceiling and underfloor (see Figure 5), as a condition of receipt of a subsidy for a new heating appliance in an effort to reduce the amount of heating required in the homes.

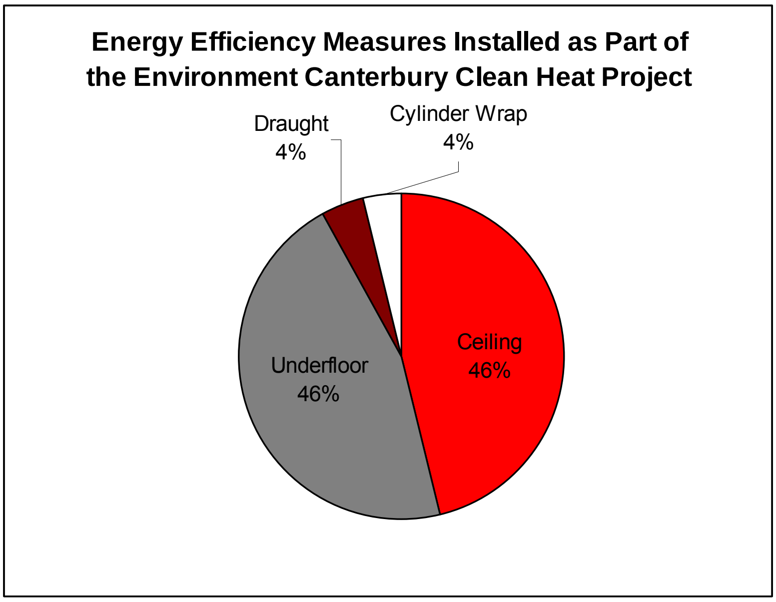

Figure 5: Energy efficiency measures installed as part of Environment Canterbury's (ECAN) Clean Heat project (ECAN 2006c)

5.3.3 Consumer laws

The Consumer Guarantees Act is able to provide some protection to consumers providing they have their heat pumps professionally installed. Service providers are bound to exercise due care and expertise when installing the item, and to provide products fit for the purpose they are intended for if they supply the item (Consumers Institute 2005b). Should problems arise, consumers are entitled to ask the service provider to rectify the situation, and should a satisfactory solution not be found, ultimately a case can be brought before the Disputes Tribunal or taken to court (Consumers Institute 2005b).

5.3.4 Future energy strategies and regulation

The New Zealand's Government recently released the draft New Zealand Energy Efficiency and Conservation Strategy (NEECS) and the draft New Zealand Energy Strategy to 2030 (NZES), with both signalling a focus on renewable power generation and an increased push for energy efficiency in all areas including residential (MED 2006a, MED 2006b).

As yet, New Zealand has no mandatory registration scheme for those installing heat pumps and air conditioners, and instead relies on manufacturers to have hand picked installers who have undergone appropriate training, and who do not guarantee the performance of their product if it has not been installed by their engineers. With the increasing installations of heat pumps, a registration scheme coupled with higher or more specific educational requirements for installers could be introduced to raise the overall standards of installations and performance.

New Zealand has no mandatory qualifications for those handling items containing refrigerants, such as heat pumps. It is, however, an offence in New Zealand to knowingly release CFCs (chloroflurocarbons), an ozone depleting substance, or hydrochlorofluorocarbons (HCFCs), a highly potent greenhouse gas, into the atmosphere during installation, operation, maintenance or decommissioning of equipment under the Ozone Layer Protection Act 1996.

The energy efficiency section of the New Zealand Building Code is currently under review. Proposed changes are to heighten the minimum required levels of insulation, as well as make double glazing compulsory after a phase-in period. This is likely to make new houses built under the new requirements more energy efficient and/or warmer than their older counterparts. Currently there are no requirements for the types or efficiency of heating systems other than resource consents. Requirements for heater types and efficiencies could potentially be introduced by regional authorities in an effort to curb greenhouse gas emissions, or to minimise electricity consumption and network loads.

5.3.5 The big wide world

In Europe, some countries have introduced registration schemes for heat pump installers to ensure they have had adequate training in the area and can be held accountable for their work (Forsén 2005).

The UK introduced the UK Ozone Depleting Substances Regulation (SI 1510/2006) in 2006, which requires any persons working with equipment containing ODS refrigerants (including heat pumps) to obtain appropriate qualifications by 9 April 2007.

In Australia, legislation governing air conditioning and heat pump unit installation differs between states (Heap 2001), with the exception of the nation-wide mandatory Refrigerant Handling License. In an effort to protect the environment from ozone depleting substances, such as the refrigerants used in heat pumps, people installing heat pumps have been required since July 2005 to have a Refrigerant Handling License (Department of the Environment and Water Resources 2005).

The USA operates a system similar to Australia's in that individual states are responsible for implementing legislation surrounding the installation of air conditioners and heat pumps, including certification for the handling of refrigerants (Heap 2001). The US Environmental Protection Agency (EPA) has federal legislation surrounding refrigerants and the emission of greenhouse gases under section 608 of the Clean Air Act, which came into force on 1 January 1992.

5.4 Human behaviour – how are heat pumps used?

5.4.1 New Zealand

Very little information on the effects of New Zealand heat pump installations is available. The most comprehensive available at the time this report was published were the two CEA surveys of Clean Heat project participants in Canterbury.

ECAN Clean Heat project

A media release for the ECAN Clean Heat project on 14 July 2005 stated that a CEA heat pump survey of a small sample of 14 homes in Christchurch in which heat pumps had been installed for two winters "found no significant increases in overall fuel costs, going from an open fire to a heat pump, and for those householders who had previously used electricity for their main source of heating, energy costs decreased" (Walker 2004).

It is widely known that open fires have an average level of efficiency of around 15%, and due to the tendency for households with open fires not to use them intensively or often (Isaacs et al 2005), they therefore cannot be compared to heat pumps with a COP of 4 at 7°C. For example, for every 1 kW of energy put into the heat pump, up to 4 kW of heat may be produced at 7°C. The media release also drew a comparison between conventional electric heating, when perhaps a fairer comparison for the cost-effectiveness of heat pumps versus more traditional forms of heating would have been a comparison against a type of heating with comparable output – enclosed solid fuel burners, for example – which heat around 52% of New Zealand's homes as compared to 11% for open fires (Isaacs et al 2005).

Higher average thermostat settings were witnessed in the second CEA heat pump survey than had been in the first, indicating that temperature expectations of the occupants are likely to increase in at least the first year after installation. Several of the heat pumps were used for fewer hours in the second year, however, apparently cancelling out much of the energy difference in heating to higher temperatures.

The use of the heat pumps for cooling was acknowledged in both CEA reports. Concern was expressed in the first report over the impact of summer cooling loads resulting from the use of heat pumps (Walker 2004). However, the second report established summer cooling was still taking place but did not discuss the findings further. In the first survey in the first year after installation, eight of 23 (35%) participants said yes, with four of the eight (17%) using the heat pump for cooling only on the "hottest days" (Walker 2004). In the second survey in the second year after installation, eight of the 14 participants (57%) responded that they only used their heat pumps for cooling on the "hottest days" (Fyfe 2005). This shows that having the technology available has enabled some of the participants in the survey to commence summer cooling, which they are unlikely to have had access to beforehand.

The results from the CEA heat pump survey (Fyfe 2005) cannot be expected to replicate resulting changes in expenditure on heating for the rest of New Zealand. BRANZ's nationally representative HEEP study of 400 houses over 10 years has found that heating patterns throughout New Zealand are highly varied, an example being the average household in Auckland turning on the heater when temperatures reached levels above the average summer temperature of Invercargill (Isaacs et al 2005), indicating that acclimatisation and other social factors are involved.

The fact that Aucklanders tend to turn on the heater at temperatures higher than the average summer temperature of Invercargill poses interesting possibilities, because Auckland houses use a far higher proportion of electricity in space heating than those living in Invercargill and Dunedin (Isaacs et al 2006), and those living in the south of New Zealand tend to rely far more heavily on solid fuel. Although Auckland houses use around half of the electricity for space heating per house as those in Invercargill and Dunedin, the population is far higher. Therefore the Auckland region has the potential for far higher electricity savings from heat pumps than Invercargill and Dunedin, where encouragement may actually increase the electricity use.

The HEEP study showed that most New Zealanders tend to heat one room in their homes during the evenings over winter (Isaacs et al 2004). The majority of houses did not heat their bedrooms, and very few heated their entire homes (Isaacs et al 2004). As the CEA heat pump survey showed, some people with heat pumps are using them to heat their entire homes, which had not been done previously (Fyfe 2005). The additional floor space would require more heat to get up to and maintain a certain air temperature, and therefore more electricity is required.

5.4.2 The big wide world

The possibility of an increase in the use of air conditioning in New Zealand is quite real, with research from the UK showing strong uptake of the technologies as the temperatures rise. In line with predictions, the sales of air conditioning units (including reverse cycle air conditioners) in Europe have "boomed" as a direct result of the 2006 heatwave, leading to concerns of a negative impact on CO_2 emissions. From estimates of 5% of homes in Europe with air conditioning released in 2006, it is predicted that this could rise to 16% by 2020 (Hamer 2006). One report suggests the possibility of the loading of domestic air conditioning contributing an additional 4.9 million tonnes (Mt) of CO_2 into the atmosphere each year in the UK alone (Wu and Pett 2006).

5.5 Impact on energy consumption and greenhouse gas emissions

5.5.1 New Zealand

Despite most of the CEA heat pump survey's sample houses having been insulated to some degree as part of requirements of the Clean Heat project assistance (see Section 5.3.2), it was found that for the 18 houses surveyed in the first 'Heat Pump Survey', the average rise in peak loadings on the coldest day of winter per house was found to have increased by 65% (Walker 2004), presumably due to the impact of the heat pumps. This additional load places extra pressure on already stretched electricity networks, and contributes to the extra 5,800 MW of electricity estimated to be needed in New Zealand by 2025 (Leyland 2004). It is also likely, due to the high proportion of Housing New Zealand houses in the study, that the majority of those surveyed were in lower income brackets, possibly living in smaller houses, and relatively unlikely to have much discretionary money available to spend on additional heating energy. Therefore the increase of 0.7 kW of peak load per house may be dwarfed by figures more representative of "average" New Zealand houses and households.

Although there was no "significant increase" in energy use overall in the CEA heat pump survey, the energy usage results for between 2002 and 2003 were highly polarised with a number of the houses in the survey experiencing considerable rises in the amount of energy and others experiencing considerable reductions in energy (Walker 2004). Of the 14 houses, 11 had had their open fires replaced as part of the Clean Heat project, and the other three were Housing New Zealand tenants. The increases may have been a result of households using their heat pumps more than they had used previous forms of electric heating, heating to higher levels than they had previously, or that they previously had not had electric heating at all. Indeed, in a follow-up report to the survey, it was acknowledged that there were significant increases in energy use in households with heat pumps in constant operation over winter, something which was advised by some heat pump installation companies (Fyfe 2005).

The CEA heat pump survey acknowledged environmental consequences surrounding the fuel type used by the heat pumps. The assumed emissions from the additional load heat pumps were placing on the electricity network were based on an estimate from the New Zealand Climate Change Office (NZCCO) that the production of the electricity used in operation generates 600 tonnes of CO_2 emissions per GWh of additional electricity generated "at the margin". The 2004 estimate from the NZCCO rose to 600 to 650 tonnes of dioxide emissions per GWh of additional electricity generated "at the margin" (NZCCO 2004). The CEA heat pump survey worked on the assumption that heat pumps were the causes of changed electricity use in the houses, but this may, for example, have been caused by changes to the use of other appliances. If the space heating had been provided not by electricity but, for example, by wood, then the effect of replacing the heating by the more efficient electric heat pump would still be an absolute increase in the CO_2 emissions.

5.5.2 The big wide world

From an international perspective, heat pumps have the ability to reduce energy consumption for heating, as most homes in developed countries usually maintain temperatures higher than those found in the average New Zealand home. As the temperature set point and heating schedules are less likely to change, there is a better chance of using the high efficiencies of heat pumps to good effect. Therefore the majority of the literature on heat pumps from international sources tended to focus on the introduction of space cooling into homes which previously used passive cooling techniques.

In the UK, projections for the uptake of domestic air conditioning suggest the CO_2 emissions from the additional electricity used could negate between 15–90% of CO_2 savings expected from Building Regulation changes in 2002 and 2006 (Wu and Pett 2006).

In Belgium, simulations have shown widespread introduction of heat pumps for heating could lead to reductions in CO_2 emissions (Peersman et al 2002). This was cited as being due to high COPs and the need for a newer, cleaner burning power plant to replace older coal fired power generation (Peersman et al 2002).

6. NEW ZEALAND ANALYSIS

6.1 Uptake of heat pumps

If approximately 70% of all single phase non-ducted split system air conditioners are installed into domestic circumstances as heat pumps, and if the estimate of 120,000 heat pumps in New Zealand houses in 2005 is correct (see Section 5.1.1), the stock of units installed into New Zealand homes as at March 2006 was likely to be far in excess of 170,000.

The domestic market may well be far larger than currently suspected, however, as in 2002 alone MEPS figures showed an estimated 231,608 split non-ducted heat pump units were sold in New Zealand (EECA 2004).

As most heat pumps that have been sold in New Zealand have a reverse cycle function (see Section 5.1.1), it is almost certain that a higher percentage of New Zealand houses currently have access to air conditioning than Europe (Hamer 2006).

6.2 Market drivers

With such a large number of New Zealand houses with heat pumps, it appears that the promotion of the heating type by government and industry alike has made a large impact with an estimated 11% of all New Zealand households possessing the technology. This narrow focus on heat pumps as a solution is likely to encourage people replacing heaters to opt for a heat pump instead of any other form of heating. The drive toward more efficient home heating in New Zealand appears to have assisted in making heat pumps a particularly popular replacement heating technology in areas with air pollution issues.

The Clean Heat project participants have shown a strong preference for heat pumps as ‘clean’ space heaters. As of 6 November 2006, 62% of Clean Heat participants had chosen to install heat pumps to replace their open fire or solid fuel burner, as seen in Figure 6. At 19%, solid fuel burners came in at a distant second.

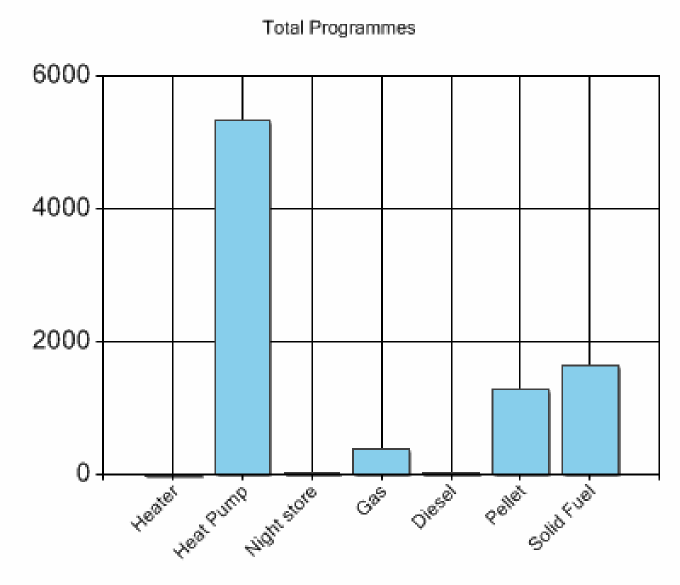

Figure 6: Environment Canterbury's (ECAN) subsidy uptake numbers of each registered heating type category as at 6 November 2006 (ECAN 2006b)

As discussed in Section 5.3.2, subsidies have been available for Timaru residents who replace open fires and older woodburners with heat pumps. No alternative replacement heating methods are subsidised in this particular program.

The lack of gas heaters being installed in Christchurch, however, can be partly attributed to the lack of a reticulated natural gas network in the South Island, so any homes with gas heaters use bottled LPG. Being a city, the relatively small number of solid fuel burners and pellet burners being installed may be due to fuel accessibility or cost issues.

Mainly through the use of subsidies and affiliated publicity, government and industry appear to be encouraging the market for heat pumps in homes, and have contributed to the installation of thousands of heat pumps in Christchurch alone (see Figure 6).

6.3 Regulation and governance

The introduction of MEPS in New Zealand has mandated the elimination of reverse cycle heat pumps with lower efficiencies in the cooling cycle. There are currently no MEPS applicable to the efficiency of the heating cycles of heat pumps on the market. Considering the predominance of heating in the active control of temperatures in New Zealand's homes, the efficiency of the cycle that is currently used most is not covered by current legislation.

Aside from electrical training, there are no compulsory qualifications or registration schemes for heat pump installers or maintenance people. Some voluntary programs, such as the Institute of Refrigeration, Heating and Air Conditioning Engineers of New Zealand's (IRHACE) "No-Loss" course (MfE 2006), have been introduced to educate tradespeople on the handling of refrigerants and to encourage the public to seek people with such qualifications.

Despite the lack of regulation and governance over heat pump installation, many New Zealand manufacturers have sought to maximise the performance of their products by guaranteeing their products only if their trained staff members perform the installation.

6.4 Impact on energy consumption and greenhouse gas emissions

Although specific to Christchurch, the CEA surveys on the ECAN Clean Heat project are currently the best indication as to the change in use of energy in households as heat pumps are introduced. As this project replaces open fires and older woodburners, it is almost certain that the overall electricity loading has been increased as a result of the installation of heat pumps. Using the CEA heat pump survey's 0.7 kW average electricity load increase per house, the Clean Heat project's approximately 4,800 houses are likely to be contributing at least 3.6 MW of additional load on the electricity network in Christchurch compared to before the project began. For the "average" New Zealand house, however, this loading is likely to be higher as the participants in the survey were low income or Housing New Zealand tenants and therefore were likely to live in houses with smaller floor areas and therefore require less heating.

Therefore it is quite possible that the increase in electricity usage may have annulled the removal of emissions of pollutants and greenhouse gases from previous sources of non-electrical heating. This is particularly pertinent, considering 25.2% of New Zealand's electricity was generated by non-renewable means (oil, coal and gas) in 2004 (Dang and Cowie 2006), only 55% of New Zealand's electricity was generated from wind and hydro generation in the year to June 2006 (Statistics New Zealand 2006), and longer-term future projections have shown an expectation for the amount of electricity production fuelled by non-renewable fuels to increase (Leyland and Mountain 2002).

The push for better air quality has seen a clear preference amongst Clean Heat project consumers for electric heating (ECAN 2006b). This has another unforeseen consequence on electricity infrastructure. The Statistics New Zealand Household Economic Survey estimated the number of households with wetback fires of any kind (fireplaces capable of heating water when in operation) to be around 14% of all New Zealand houses (or 209,000 households) in the year from 2003 to 2004. Although there has been a significant decline from 22% of houses (or 241,000 households) in the year from 1985 to 1986, there is still a significant amount of hot water produced by non-electric means. Indeed the HEEP study showed that approximately 5% of the energy used for heating water in New Zealand was supplied by wetback (Isaacs et al 2005). It also observed that in colder climates especially they appear to be making a large contribution to the management of peak loadings in winter (Isaacs et al 2005). Although they tend to have higher standing losses than electric cylinders, the elimination of wetbacks due to the push for electric forms of heating has the potential to have ramifications on the electricity infrastructure in typically rural areas with cold climates, often with limited electricity supply capacity (Isaacs et al 2005).

Another aspect to the elimination of wetback water heating due to the market transformation of home heating is that those who previously had wetbacks become reliant on the national grid for water heating. Whilst beforehand households were able to get independent space and water heating from their solid fuel burner with wetback, the transition to all-electric space and water heating would mean that at any time when there is the loss of electricity supply to their property/properties they would lose the ability to heat water and their homes, as was clearly demonstrated in the winter storms of 2006. Even if the households had natural gas or LPG fuelled hot water cylinders or instant hot water, there are some models that require electricity to run.

Recent commitments to improve New Zealand's energy security suggest that the likelihood of power disruption will decrease in the future, but will not disappear entirely. The draft NEECS and the draft NZES both show an emphasis on maintaining the security of services (MED 2006a), (MED 2006b). While preference is for renewable energy, the security of supply has been placed as a higher priority (MED 2006a). While these measures may prevent most brown or black-outs, there will still be occasions where power will be lost to communities through human error, equipment failure or weather events.

Many older models of heat pumps were manufactured to utilise HCFC refrigerants, the importation of which are due to be banned under the Montreal Protocol in 2015 (MfE 2001) due to their ozone depleting properties as well as their potency as a greenhouse gas. HCFCs pose far less danger to the environment than CFC refrigerants, the importation of which was phased out in 1996 (MfE 2006). However, many older refrigerators, and car and industrial air conditioning units, still contain CFCs. CFCs are far more potent as a greenhouse gas and also are an ozone depleting substance. It is possible that a very small number of heat pumps containing CFCs exist in New Zealand's homes.

Environment Canterbury acknowledged the environmental threat posed by HCFCs with the Clean Heat project by excluding any units containing HCFCs as "Registered Technologies" after 1 January 2004 (ECAN 2006b). There is a tendency for higher quality and newer units to be hermetically sealed.[6] This means that, at least during their operating lifetimes, leaked refrigerants should remain contained, theoretically allowing them to be disposed of safely at the end of the life of the heat pump. It is, however, highly unlikely that all heat pumps will be disposed of properly so that the refrigerants can be captured, rather than released into the environment upon destruction, especially in New Zealand where firms currently have no extended producer responsibility.[7] Older units containing HCFCs still pose a potentially significant threat to the environment, even in small numbers.

While New Zealand government bodies concerned with energy efficiency are endorsing and encouraging the widespread installation of heat pumps in New Zealand's houses, overseas studies have found conflicting evidence surrounding the supposed environmental benefits of the technology. It has been suggested that there is a strong possibility of increased CO_2 emissions, if not due to increased length of heating and thermostat settings, as witnessed in the CEA heat pump survey, then due to the widened availability of air conditioning from heat pumps in warmer weather (EEBPP 2000). This is likely to exacerbate summer electricity supply issues, especially in warmer, densely populated areas such as Auckland.

7. TRENDS

With the phenomenal popularity of the heat pump in New Zealand, its rise can be traced back to many causal factors. This section looks at some of the major trends which have influenced the market to adopt heat pumps as it has, and look at how they might affect it in the future.

7.1 New Zealand heating and cooling patterns

Historically, New Zealanders have had a tendency to underheat their houses. The HEEP study found that the mean living room temperatures from August to September in a Statistics New Zealand study from 1971 were cooler in the northern part of the North Island by around 1.2°C and 0.5°C in the southern part of the North Island (Isaacs et al 2004). The average living room temperatures in August and September in homes in Christchurch were warmer by around 0.9°C and in the southern part of the South Island by around 0.9°C (Isaacs et al 2004). The average winter living room temperatures of New Zealand's houses are below 18°C (Isaacs et al 2004), the

[6] Personal correspondence with Stan Redit of CozyCool, Porirua, New Zealand.

[7] Extended producer responsibility is where producers are liable for their products, even after sale, leaving them responsible for disposal or recycling of the good and any substances they contain.

minimum temperature for occupied living areas, and nearly 25% are below 16°C, the minimum temperature for bedrooms for maintaining good health as recommended by the World Health Organisation (WHO 1987).

Table 3: Winter living room evening temperatures by heater type as found in the HEEP study (Isaacs et al 2004)

Heater type	Temperature (°C)	Standard deviation	Sample count
Open solid fuel	16.0	0.5	12
Electric	16.9	0.3	83
LPG	17.1	0.2	54
Fixed electric	17.8	0.3	19
Solid or liquid fuel central	17.9	0.2	2
Gas	18.0	0.5	26
Heat pump	18.0	0.4	4
Gas central	18.3	0.7	7
Enclosed solid fuel	18.9	0.2	138

In order to improve the energy efficiency of New Zealand's housing stock, a minimum insulation standard for new-build New Zealand houses was introduced in mid-1978. As a result, the HEEP study found the average winter living room temperature in post-1979 houses to be an average of 1°C warmer, and the bedrooms were, on average, 1.3°C warmer despite being of a larger floor area on average.

It has been found that the average winter living room temperature of homes has a tendency to relate to the type of heaters they use (see Table 3). The coldest houses tend to have open solid fuel burners (open fires), electric heaters and LPG heaters. The warmest tend to have heat pumps, gas central heating and enclosed solid fuel burners (woodburners).

With the introduction of summer peaks in electricity use, a new challenge has been issued to New Zealand's electricity sector. The brown-outs experienced in Auckland over recent years have been in summer when air conditioning is at its peak. The majority of users of electricity for cooling have traditionally been commercial buildings. However, increasing numbers of homes are having heat pumps installed which are, by default, reverse cycle air conditioners. With convenient access to air conditioning, many households are likely to utilise it to maintain comfort levels when exterior temperatures or humidity levels are high.

The internal environments of New Zealand's houses are being more highly controlled than ever before, both passively with insulation and actively with heating and cooling. This poses new challenges for New Zealand's infrastructure and demonstrates the growing demand for comfort amongst New Zealand consumers, despite the expense of energy, a trend which is likely to continue.

7.2 Where we are

There has been an increase in residential power consumption, both overall and per consumer, over the past few years in New Zealand (MED 2006c). It is possible that this increase over the past few years may in part be related to the growth in sales and the preference demonstrated by the market for heat pumps.

There could be in excess of 170,000 New Zealand households using a heat pump unit as their main heater – there is no information available surrounding the numbers of homes with more than one unit. If half of these were installed into New Zealand houses to replace solid fuel burners (open fires or enclosed woodburners) as the principal source of heating, this would mean the use of heat pumps may have raised the electricity loadings for the residential sector by an average of around 60 MW. Assuming an average draw of 1.7 kW during peak loading periods in winter, nearly 145 MW may have been added to the electricity networks. Therefore it is possible that an additional load of more than twice the 67.98 MW capacity of the Tararua Wind Farm (TrustPower 2006) may have been created by heat pumps alone since 2000.

Rather than the heat pumps themselves, it is the fuel that heat pumps rely on (electricity) which should be the target of misgivings. From producing power through mostly renewable means, New Zealand began to witness a decline in the ability for renewable power generating technologies to supply New Zealand's burgeoning demand until recently. Now, with the Kyoto Protocol coming into force and a renewed focus on sustainability, this is being addressed with a focus on the construction of renewable power generation to supplement the existing capacity, as demonstrated in the draft NEECS (MED 2006a), and the draft NZES (MED 2006b). As the price of fossil fuels has increased, and the concern for human induced climate change has become mainstream, the long-term benefits of renewable energy has seen the option become more feasible perhaps than fossil fuelled power generation. Resource consents and environmental planning, while necessary to protect the environment and the rights of the people of New Zealand, have delayed some renewable energy projects from being built. Therefore it has been seemingly easier in the past for power generators to build fossil-fuelled power stations, which have smaller physical footprints, if not ecological.

Since 1996 four grid-connected fossil-fuelled power plants have been commissioned in New Zealand. In December 1995 the Southdown cogeneration plant, fuelled by natural gas and producing electricity and steam, began operation (Mighty River Power 2006). In July 1998 the Taranaki combined cycle gas turbine power station was completed (Contact Energy 2007). The Otahuhu B combined cycle power station was commissioned in January 2000 (Contact Energy 2007). In 2004 the diesel-fired Whirinaki power station in the Hawkes Bay was opened to provide reserve generation during shortages. Renewable power generators in New Zealand typically have smaller capacity than their fossil-fuelled counterparts. However, as the demands of the Kyoto Protocol come upon New Zealand, the electricity sector is beginning to favour renewable resources for producing electricity. Six wind farms have been commissioned in New Zealand since 1996 (NZ Wind Energy Association 2007), and a 16 MW binary plant added to the existing Wairakei geothermal power station in 2005 to improve generation yield and efficiency (Contact Energy 2007).

8. SCENARIOS

8.1 Continuation of current trends

Should current trends continue, the growth in sales of heat pumps will go on unabated. A combination of market drivers, government and government body policies, legislation and public perception is likely to see the demand for heat pumps continue to grow, and the removal and replacement of grid-independent means of heating continue. Already there is clear evidence that heat pumps are now preferred over any other form of 'clean' heating by consumers, governing bodies and industry.

8.2 Increasing and implementing insulation requirements

With the latest activity surrounding the Building Code, it seems almost certain that an increased standard of insulation as well as double glazing will become mandatory in new-build New Zealand houses in cold areas (Zone 3) from mid-2007. Increased levels of insulation may reduce the heating loads during winter, but have the potential to increase summer indoor temperatures, as witnessed in the HEEP study. This slight increase may push the temperature range over current comfort thresholds for cooling, thereby creating higher loadings in summer from air conditioning.

A recent update to the New Zealand standard NZS 4218: 1996 is NZS 4218: 2004 Energy efficiency - small building envelope. According to the DBH, the change "limits the use of the schedule method to houses with areas of glazing 30 percent or less of the total wall area" (DBH 2006). This revision to the standard may go some way towards discouraging overglazing in new houses. While this may assist in decreasing the overheating and overcooling problems in many new houses, the gradual introduction of double glazing could potentially increase or maintain overheating tendencies of modern houses. Increased overheating may lead to the need – real or perceived – for air conditioning in some houses to maintain comfortable temperatures.

As seen in the CEA heat pump survey, expectations of comfort may be increasing in Christchurch. Although there is no evidence as yet, it is likely that comfort expectations may be increasing in New Zealand, as part of the western world, as consumers constantly seek to increase their quality of life. For this reason, in the event that older houses are required to retrofit insulation under legislation, the electricity consumption for New Zealand's houses could very well remain the same over winter due to the apparent tendency for consumers to value additional temperature over monetary savings (see Sections 5.4.1 and 5.5.1). Houses will become warmer as the amount of heat retained by the houses increases, but this will happen both in winter and summer. Warmer indoor temperatures during cooler periods are likely to reduce cold-related mortality. Higher indoor temperatures in summer, heightened demand for comfort, and the widespread uptake of heat pumps with air conditioning capabilities could contribute to higher summer energy consumption in New Zealand if the UK's experience is anything to go by (Hamer 2006).

While warmer indoor environments are likely to reduce cold-related mortality, increased indoor temperatures on warm days may lead to increased air conditioning loadings due to the pursuit of comfort. Heat pumps are able to assist in actively modifying the temperatures within spaces to comfortable and healthy levels for occupants leading to many non-energy benefits, and increase energy loadings during both winter and summer as comfort expectations increase.

8.3 Removal or reduction of government subsidies

Currently central and local government are promoting heat pumps as an energy efficient form of heating, while some local government bodies are supplying subsidies for the installation of heat pumps among other heating technologies. By removing subsidies for heat pumps, local government would be sending out a signal that heat pumps are no longer the most sustainable and preferred method of heating in New Zealand. This could potentially be damaging for the market, and devalue the technology without warrant. Heat pumps themselves are still the most efficient form of electric heating on the market, and therefore deserve to be subsidised when other forms of heating are also being subsidised.

If the numbers of subsidised models for each of the currently-favoured heating technologies were balanced out, and advertising and promotion favouring one technology over another were removed, it would be possible to continue the implementation of clean heat technologies into New Zealand homes, allowing for less emotive selection of technologies based on impression and what was considered to be "good" and appropriate according to market drivers. Emphasis could be placed on assisting people to choose appropriate forms of heating in accordance with their preferences, lifestyles and circumstances through education as well as through eco-labelling and green ratings.

8.4 Decline in market drivers

Government agencies and energy providers have been driving the market by promoting heat pumps for several years in New Zealand, and have contributed to a three-fold increase in yearly sales figures from 2001 and 2005.

With the removal of this publicity, the number of heat pumps sold is likely to continue to increase through word of mouth, heightened availability and retailers. Most New Zealanders are aware of heat pump technology, and therefore are likely to consider it as an option when purchasing, renewing or upgrading their heating systems.

8.5 Increased price of electricity

Recently there has been substantial publicity surrounding electricity shortages in New Zealand, and the impact that climate change could potentially have on electricity generation, causing the price of electricity to rise. This may see some households revert to more traditional sources of fuels as electricity becomes too expensive for people to justify using for space heating purposes.

If this were to eventuate, an overwhelming number of heat pumps could have a negative impact on the temperatures in New Zealand's houses. People may turn their heat pumps off, run them on timers, or at a lower thermostat temperature so as to conserve energy. Those who cannot afford to replace or complement heat pumps with heating methods using other fuels might live in cold houses, as many do now. A glut of heat pumps being used in New Zealand houses is likely to, as shown in the literature review, lead to increased peak loadings, and thereby larger generation capacity requirements. In this case wood as a fuel would be perhaps the most sensible option outside large urban areas, and particularly for rural and provincial areas, especially as it does not contribute to the greenhouse gas emissions according to the IPCC (MfE 2006), and that plantation forests are regarded as carbon sinks (NZCCO 2004). Particulate emissions may remain an issue in some New Zealand towns and cities. However, high efficiency wood burners used properly are able to meet 'clean air' standards.

8.6 Living room temperatures

There are a number of factors that could potentially see a rise in the average temperatures of New Zealand's living rooms during winter. As New Zealanders become more aware of the health and well-being benefits of warmer homes, they are likely to heat to higher levels, extend their heating hours and season and, as a result, use more energy in heating. Heat pumps have the ability to assist in this result.

Heat pumps are usually far more efficient than a standard electric heater, and thereby use less electricity when heating to identical levels and schedules. This benefit has a tendency to be lost, with occupants using the more effective form of heating to increase the temperatures in the house, heat more rooms than previously, or heat for longer periods of time. Some heat pumps do not allow the user to select a thermostat setting of less than the WHO's recommended minimum temperature of 16°C (WHO 1987), a temperature higher than the average evening winter living room temperature of nearly a quarter of New Zealand's homes (Isaacs et al 2004). Anecdotal evidence suggests people value warmth more than savings, and are therefore likely to increase the heat rather than retain the same or similar temperatures and pocket the savings.

8.7 Overglazing

Many buildings and houses, especially those built in New Zealand from around 1990, tend to have larger areas of glazing compared to more traditional New Zealand designs, such as the bay villa. There are many houses with floor-to-ceiling single glazed windows facing north to west, leading to overheating in summer and large heat losses in winter. Overheating provides additional territory for heat pumps, as it is just as problematic for human health and comfort as underheating.

Many consumers prefer to purchase a solution to their concerns rather than modify their behaviour. Instead of changing the way homes are designed to reduce or rectify overglazing issues, many consumers would rather install air conditioning. The latest marketing from heat pump installers and manufacturers has emphasised the air conditioning capabilities of certain heat pumps as another summer approaches, as seen in Figure 7.

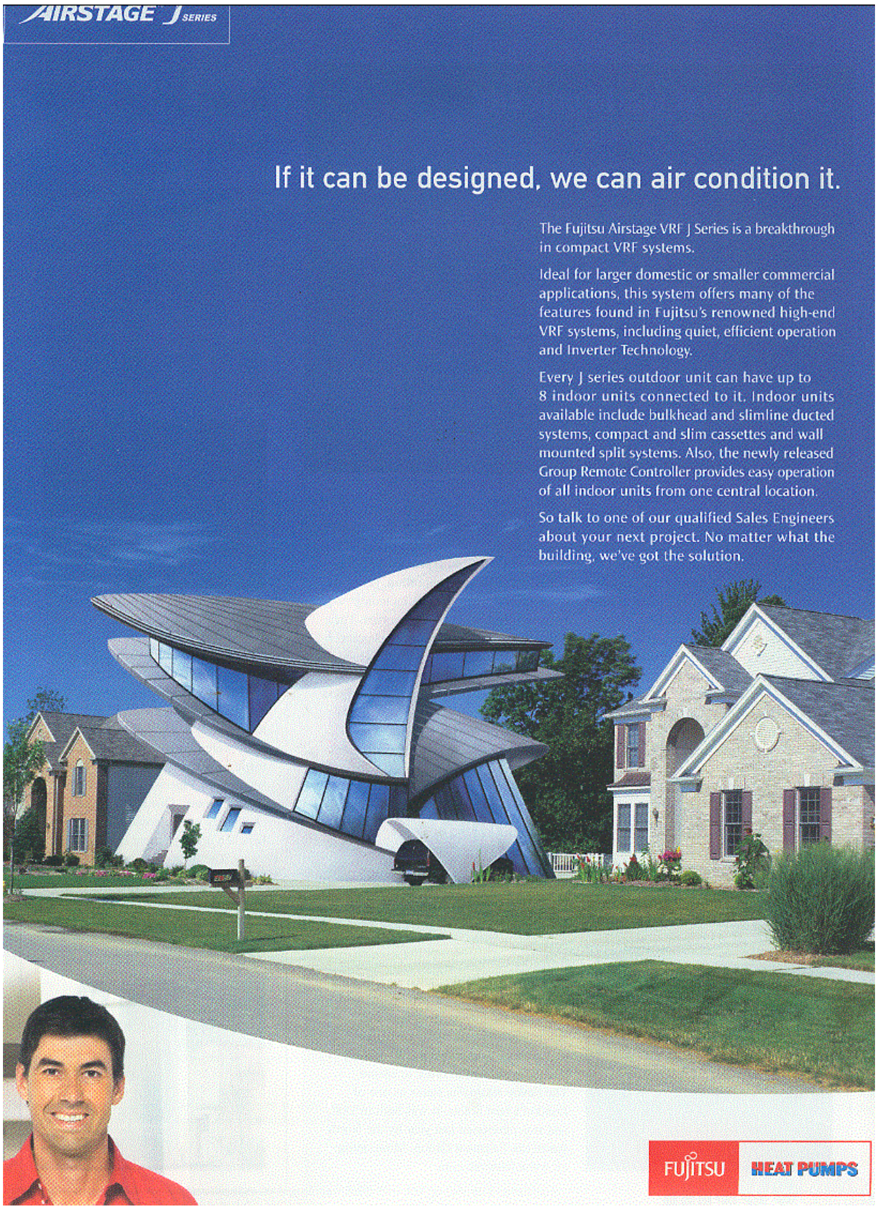

Figure 7: Heat pump manufacturer Fujitsu displays the ability of their heat pumps to air condition regardless of design.

9. CONCLUSION

New Zealand's methods of domestic space heating are shifting from more traditional approaches, and with changes come shifting burdens on infrastructure. Heat pumps are highly efficient users of electricity and higher quality ones pose little environmental risk in themselves. Even considering the greenhouse gases many contain, the types of behavioural changes their use invokes and their rapid rate of uptake may well create an unacceptable load on the electricity systems in New Zealand over the coming years.

With increased electricity generation, in order to cope with the burgeoning demand for electricity comes higher emissions of the greenhouse gases New Zealand is trying to reduce in order to conform to the Kyoto Protocol.

As the UK's *40% House* study found, it is unlikely that there will be any carbon emission reductions by 2050, even with increased efficiency and awareness, "if society continues to develop under current trends" (Boardman et al 2005). These results are likely to be the same in New Zealand due to the similarity of the western lifestyle. This is in part because of increased comfort expectations driven by consumer attitudes, and constant technological change, which sees new and additional power-consuming appliances introduced into households with the passing of time. Therefore, the greatest effect that heat pumps can be expected to have on New Zealand's homes is a higher level of heating done with the same amount of electricity where electric heating is used currently.

It can be argued that the additional electricity required to run heat pumps in New Zealand houses would have eventually needed to be created anyway, and that by slowing the installation of heat pumps it is likely that electricity network upgrades and the addition of capacity would merely be delayed rather than reduced. It is also possible that upgrades in the technology and efficiency of New Zealand's heating methods could end up lagging behind the rest of the world, the temperatures of New Zealand's houses could remain low, and the detrimental effects of cold housing could remain at current levels.

It is acknowledged that severe weather events, where temperatures drop to levels below the minimum required for the operation of most modern heat pumps, are few and far between in the parts of the country where most people live and that the coldest periods are most likely to be overnight and outside of the usual hours of heating for most people. However, this still means that unless other adequately sized types of heating are available, occupants have little or no heat available to them when the temperatures are the lowest and when they are arguably the most vulnerable. This is an important issue in the coolest parts of New Zealand.

It must be realised that the issues investigated by this report are not due to the nature of heat pumps themselves. There are many factors that have contributed to the current situation we now find ourselves in. A few of these are the chronic underheating patterns of many of New Zealand's houses, the insulation levels and ways our houses have been built over time, the methods of electricity generation in New Zealand, and the information pushed by those driving the market that combine to create the current situation.

Heat pumps are still in their infancy as a heating method in New Zealand. It is possible that they could assist in rectifying the current situation where the average New Zealand living room barely gets warm enough to maintain healthy, let alone comfortable, temperatures. Their high overall efficiencies suggest they could be a tool to assist in making New Zealand's homes warmer with smaller increases of electricity than could be expected with less efficient electric heating, providing they are heating homes that were reliant on electrical methods for heating prior to installation.

The rapid uptake of heat pumps as replacements of existing electric space heating in New Zealand could be seen as an opportunity to lower overall greenhouse gas emissions as part of the commitment to ratifying the Kyoto Protocol. However in order for this to happen, heat pumps cannot be seen as a total solution to the current situation New Zealand finds itself in.

Regulation is a strong tool for controlling and manipulating the market. However, market drivers have been successful in transforming the marketplace and consumer attitude. It is questionable which of these removes more freedom – regulation removes choice, while market drivers pressure a choice.

While heat pumps are being put forward as a solution, there is little emphasis on retrofit insulation of houses set to have a heat pump installed, except in programs funded by local government. This could lead to larger and often more expensive heat pumps being installed, costing more in electricity and affiliated CO_2 emissions to run than smaller units in appropriately sized, insulated environments. If a holistic approach were to be taken, energy efficiency could be taken to a higher level – heat pumps may have high efficiencies compared to other forms of heating, but the houses still require just as much heat to keep them warm unless other interventions, such as insulation for example, are employed. Should the average COP of the typical New Zealand domestic heating unit reach those more similar to heat pumps, the electric loadings of these houses would be the equivalent of what they are today. If all currently uninsulated homes were insulated, it could enable them to make the most of the benefits of advanced technologies such as heat pumps now and into the future, and therefore go further toward ensuring the future energy efficiency of today's uninsulated homes.

If retrofitted insulation were to become mandatory in the future, previously uninsulated homes with existing heat pumps would be left with an oversized unit. Larger units generally cost more to install upfront and run compared to their smaller counterparts, so it is likely that those who invested in the technology would have spent more on the extra capacity of the heat pump, and those living in the house after the transition are likely to end up paying for more electricity than is necessary. This would also mean that the indirect emissions from the heat pump through the generation of electricity would likely be higher than if the house had been insulated in the first place.

Higher MEPS stringency could assist in increasing the overall performance and energy efficiency of the stock of heat pumps yet to be installed in New Zealand. MEPS might be extended to include minimum efficiency requirements for the heating cycle of heat pumps as the majority are used for heating more than cooling. The ban on the importation of HCFCs could be brought forward to reduce the potential collective volume of greenhouse gases in units, thereby reducing the potential threat of release upon destruction when the appliance is installed, maintained, operated, removed or replaced. It could be made mandatory that consumers who purchase or install heat pumps be supplied with simple and clear information on how best to use and maintain them.

In partnership with increased MEPS stringency, eco-labelling (as opposed to energy rating) could be used to inform consumers how their appliance rates in the marketplace at the time they purchase them new. A complementary feature to the energy rating could be an environmental rating scale. Units could be rated based on a combination of factors, such as the global warming potential of the type of refrigerant they use, whether or not the manufacturer takes extended product responsibility (EPR), the proportion of recycled materials, and the greenhouse gas emissions from transport of the good for example.

In order for heat pumps to be more able to assist in improving energy efficiency in New Zealand, the quality of installation could be regulated through an installation code and through a mandatory registration scheme for heat pump engineers similar to that of electricians and plumbers in New Zealand. An installation code would allow standards to be set regarding the methods of installation and also the sizing of heat pumps. Mandatory registration would enable higher educational levels of installers to be maintained, particularly surrounding installation and the handling of refrigerants, make installers more accountable for their work, and could allow consumers a better guarantee of quality of instalment as well as greater peace of mind should they have a complaint.

The elevation of electricity demand due to switching from solid fuel burners to electrical air source heat pumps must be recognised in New Zealand, and action taken to ensure the market transformation is controlled and appropriate.

This report delves into many of the possible effects of the widespread installation of heat pumps in New Zealand homes, however there are likely to be many more impacts than are currently realised. This report has been limited by the availability of data on the importation and installation of heat pumps. The Government holds data on heat pump importation, and it could contribute usefully to the debate in a way that does not breach confidentiality.

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