Confidential

Review of unflued LPG cabinet heaters

Report to Ministry of Economic Development

25 May 2010

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

NZIER was established in 1958.

Authorship

Prepared by:	Peter Clough
Quality approved by:	Jagadish Guria
Date:	25 May 2010
Version:	3
Acknowledgements:	Assistance is gratefully acknowledged from John Yeabsley of NZIER, Jayne Metcalfe of Emission Impossible Ltd, and the various members of the inter-departmental steering group of this review who provided feedback on the drafts, and also the numerous individuals and organisations who gave their time and information during the consultation stages of this review

8 Halswell St, Thorndon
P O Box 3479, Wellington
Tel: +64 4 472 1880
Fax: +64 4 472 1211
econ@nzier.org.nz
www.nzier.org.nz

NZIER's standard terms of engagement for contract research can be found at www.nzier.org.nz.

While NZIER will use all reasonable endeavours in undertaking contract research and producing reports to ensure the information is as accurate as practicable, the Institute, its contributors, employees, and Board shall not be liable (whether in contract, tort (including negligence), equity or on any other basis) for any loss or damage sustained by any person relying on such work whatever the cause of such loss or damage.

Executive summary

Unflued LPG cabinet heaters (cabinet heaters) are portable heaters incorporating a 9kg LPG bottle designed to be used indoors. They pose some risk of fire, leakage and carbon monoxide (CO) poisoning, and vent their exhaust gases into the indoor air around them which, without adequate ventilation, can degrade indoor air quality with a variety of adverse consequences to health. Concerns have arisen about their continuing suitability for use, particularly in residential settings.

Cabinet heaters were introduced into New Zealand in the late 1970s in response to the energy crises, but statistics on them are fragmented and difficult to reconcile. They are a subset of the broader categories of bottled gas and unflued gas, the larger figures for which have sometimes been used to give an inflated impression of the number of cabinet heaters in homes. From this review it is likely that there are around 450,000 to 500,000 cabinet heaters in New Zealand, and that they are found in around 310,000 households (21% of the national total), with the balance in use in commercial and industrial settings like restaurants and workshops.

In recent years cabinet heaters have provided around 300-360 GWh of heat energy, around 24% of residential space heating energy and 8% of total residential energy. This equates to 1-1.3 PJ, around 12-17% of total LPG use. Both figures of LPG sales and surveys of household heating use suggest the use of LPG heating has declined over the past 3-4 years in face of increases in LPG prices. Further decline would have little impact on the LPG distribution sector other than reducing the volume of imported LPG, but a rapid decline and transfer of heating load to electric heaters as the next most likely alternative could be sufficient to bring forward the date of new investment in electricity generation and distribution facilities.

The benefit of cabinet heaters comes from reducing the risks of being cold and uncomfortable, and stem from their controllable source of heat, ability to rapidly warm the area around them, their portability, independence from interruptible reticulated supplies and the ability to pre-pay a volume of energy for budgetary purposes. The financial costs to the user come from costs of purchase, operation and maintenance. Compared to other heating options, cabinet heaters have among the lowest purchase price, but they also have among the highest operational costs (mainly fuel). Combining operational costs with annualised purchase cost the cabinet heater has among the lowest total cost per year of any heating option available for low heating tasks, but becomes among the least economic as heating demands increase. Their most economic use is as a supplementary heating source for situations that are hard to heat in other ways, rather than as a household's principal source of space heating.

There are also a number of non-financial costs associated with the heaters:

- Risk of fire and explosion, the economic effects of which include property damage, medical treatment costs, loss of life quality and premature death

- Adverse impacts on indoor air quality, due to emission of nitrogen dioxide (which affects respiratory system), formaldehyde (a toxic gas and carcinogen), water vapour (which stimulates mould and exacerbates asthma) and carbon monoxide (a toxic gas that can cause asphyxiation) – the economic effects of which include lost production from days off work or school, increased medical treatment costs, loss of life quality and premature death
- Indoor moisture effect on the structure and furnishings of buildings, the economic effects of which include accelerated depreciation and repair costs.

Many of these non-financial costs affect people other than those directly affected – e.g. employers, landlords and funders of public health services – so there is a risk of decisions on whether to use cabinet heaters based on the apparent costs of heating creating wider "hidden" costs on the community at large. However, these effects are not all classic "externalities" falling on third parties, as a large part of the hidden cost is borne by those using the cabinet heaters themselves. This suggests there may be a market failure in information about the costs and consequences of using these heaters, the response to which would be in helping people make better informed decisions about their purchase and use.

A survey of literature conducted for this review found many studies of unflued gas heaters in general, but little on cabinet heaters in particular. A number of health and safety concerns with unflued gas heating venting into indoor living spaces have been identified internationally and within New Zealand, but there is relatively little relating this to quantifiable measures such as how deteriorating air quality increases days off work or doctors' visits. Although unflued gas heaters including cabinet heaters appear incongruous with the drive for better home insulation and energy efficiency, this review has not found evidence of a worldwide trend towards curtailing the use of cabinet heaters. They are still used in a number of countries, and in countries such as Australia and USA where they are not, their non-introduction was due more to concerns about fire safety than about their effects on health.

A wide variety of people and organisations with an interest in cabinet heaters were interviewed in the course of this review. Most of those interviewed were concerned with the hidden non-financial costs of their use. Continued use of unflued heaters was viewed as inconsistent with other government moves to increase the energy efficiency and insulation of New Zealand's housing stock. While recognising that removing a heating option might have adverse consequences on health, there was little consensus on how to manage the hidden costs while providing alternative sources of heat. Opinion spanned a broad range from banning cabinet heaters entirely, to those who regarded them as a useful option with a role to play, with perhaps improvements in information and design to reduce their potential adverse effects. Among those from both sides of that range of opinion there was a degree of common recognition that using cabinet heaters as the principal source of household heating should not be encouraged. This is borne out by the comparison of operating and ownership costs of different types of heating in this review.

In estimating the social costs and benefits of such heaters, it is necessary to establish the difference in benefits net of costs between such heaters and the next best alternatives to them which for this review are assumed to be electric plug-in heaters. But these are not perfect substitutes, and in the absence of LPG cabinet heaters there would be some loss of functionality under that alternative scenario. Other, more efficient heating options (like heat pumps) are not considered to be most likely alternatives because they are fixed installations and involve substantial financial hurdle to overcome in purchase and installation.

Relative to the alternative of electric heaters, cabinet heaters provide:

- Benefits from their ability to rapidly warm the area around them, independence from interruptible reticulated supplies and the ability to pre-pay a volume of energy for budgetary purposes, measured by willingness to pay for LPG cabinet heating over and above the next best alternative
- Benefit from lower greenhouse gas emissions from direct gas combustion, compared to energy conversion losses from thermal electricity generation
- Costs in the additional maintenance required for LPG cabinet heaters
- Costs from increased risk of fire and injuries and property damage
- Costs of impaired health particularly for children with asthma.

Costs and benefits not capable of being quantified on current information include the benefit of deferring investment in electricity capacity, the cost of health effects for other age groups, and the cost of additional moisture on property maintenance.

The net result of quantified costs and benefits shows estimated costs far exceed the benefits. The benefit estimates, based principally on users' willingness to pay for LPG over what they could pay for equivalent heat from alternative heaters, suggest users value attributes of cabinet heaters other than just heat. There is also benefit from reduction in greenhouse gas emissions from direct combustion of LPG, compared to heating from electricity generated by thermal-fired plant.

The principal cost is the health effects on children with asthma. While cabinet heaters may cause additional costs to other age groups, or those with other respiratory conditions than asthma, the scientific literature surveyed in this review does not find statistically significant health effects for these other groups in the population from indoor air pollution of cabinet heaters. This does not mean health effects are non-existent for other age groups, but they are unlikely to be large and pervasive.

The costs associated with risk of injuries and property damage from fire and CO poisoning are relatively small by comparison, far less on their own than both the health costs and the estimated benefits of cabinet heaters.

The benefit estimates are subject to the proviso that some of the increased willingness to pay for LPG may reflect mistaken views about its economy rather than real preference for its benefits. There is no reliable information on the proportion of cabinet heater users who may be mistaken in this way and are paying too much for heat, rather than paying extra for non-heat benefits. The estimated health cost of cabinet heaters may be overstated if recent changes in LPG use have reduced the exposure of asthmatic children from historic levels. But it may also be under-stated if those other than asthmatic children also suffer significant health effects from exposure to cabinet heaters.

Uncertainties and data limitations in the quantified cost benefit analysis make it difficult to be precise about the net cost of using cabinet heaters to New Zealand, but there is evidence to suggest substantial hidden costs, particularly in the health area rather than in safety risk and cost of operation that tend to receive more media attention. Reducing these costs without incurring greater costs and risks in the process would be beneficial for New Zealand. Health costs are predominantly borne by a minority of the population – children with respiratory conditions – so reducing their exposure to cabinet heaters would reduce health costs. Health costs so dominate the quantified balance of costs and benefits, and are so concentrated in an albeit sizable minority of the population, that if health effects could be reduced by targeted measures on those at risk, extending intervention to more general measures across those less susceptible to health effects is unlikely to provide additional net benefit.

This review has considered a number of intervention options that have been suggested, with the aim of reducing the hidden costs without creating greater costs through deprival of the benefits that LPG cabinet heaters provide. Some of the suggested options are not particularly focused on reducing costs without undue deprivation of benefits. While there has been concern over an apparent increase in the number of fire and CO incidents in recent years, these incidents are still relatively uncommon and most incidents appear to be due more to human error than to failures of the appliance. The cost benefit analysis suggests that a larger problem lies with the health effects of use of these heaters, which also reflect how they are used and observance of the recommendations for safe and proper use.

In light of the findings of this review, further investigation would be warranted into the less intrusive options, in particular the effectiveness of information dissemination on safe use of cabinet heaters in reaching users and changing behaviour, and in targeting those susceptible to the health risks identified in this review.

There may be a failure in information dissemination that could be addressed by improving labelling of appliances with safe use information. This review has not found conclusive evidence of a market failure large enough to warrant stronger or more widespread measures which carry greater risk of costs and deprival of benefits that cabinet heaters provide.

Contents

1. Introduction 1
1.1 Background 1
1.2 Framework for analysis 2
1.3 Outline of report 4
2. Current and previous views on cabinet heaters 5
2.1 A brief history of cabinet heaters in New Zealand 5
2.2 Previous consideration of cabinet heaters in New Zealand 6
2.2.1 The role of government agencies 8
2.2.2 Regulation of unflued LPG gas heaters in New Zealand 10
2.3 Consultation on use of cabinet heaters 11
2.3.1 The benefits of cabinet heaters 11
2.3.2 The risks and costs of cabinet heaters 12
2.3.3 Suggestions for addressing problems with cabinet heaters 15
2.4 Summing up 17
3. Current uses of cabinet heaters in New Zealand 18
3.1 How many cabinet heaters are there? 18
3.2 How are cabinet heaters typically used? 21
3.3 The cost of unflued LPG cabinet heating 22
3.3.1 Operating costs 22
3.3.2 Capital costs of cabinet heaters 24
3.3.3 Combined costs of space heating appliances 25
3.4 Trends in consumption and pricing of LPG 27
3.4.1 The effect of insulation and clean heat subsidies 29
3.4.2 Cabinet heaters and national energy consumption 30
3.5 Social cost of injury and property damage 33
3.5.1 Injury data 33
3.5.2 Social cost of injuries 34
3.5.3 Cost of damage to structure and house contents 35
3.5.4 Total social cost 37
3.5.5 Data gap and consequences 38
3.6 Social cost of health effects 39
3.6.1 Effects of nitrogen dioxide 39
3.6.2 General effects 40
3.6.3 Asthma quality of life 41
3.6.4 Social cost estimates 43
3.6.5 Including all children up to 17 years old 47
3.6.6 Summary of assumptions and limitations 49
3.7 Effects of household moisture levels 50
4. The balance of costs and benefits 52

4.1 Defining the counter-factual ... 52
4.2 The value of benefits of cabinet heaters ... 54
4.3 The value of costs of cabinet heaters ... 55
4.3.1 Supply costs ... 55
4.3.2 Greenhouse gas emissions and outdoor air quality ... 57
4.3.3 Accident and safety risk ... 58
4.3.4 Health and quality of life risk ... 58
4.3.5 Building operation and maintenance cost ... 59
4.3.6 Summing up the cost benefit analysis ... 59
4.4 Future directions of costs and benefits ... 62
4.5 Caveats around these results ... 62
4.6 Implications of results ... 64
5. Options for improvement ... 66
5.1 Reasons for intervention ... 66
5.1.1 Application to cabinet heaters ... 66
5.1.2 Pointers on policy for cabinet heaters ... 68
5.2 Options for addressing problems with cabinet heaters ... 69
5.2.1 Improved information dissemination on safe and healthy use ... 69
5.2.2 Develop standards applying to cabinet heaters ... 70
5.2.3 Withdraw use of heaters from institutional settings ... 71
5.2.4 Increase subsidy assistance for cleaner heat to low income households ... 71
5.2.5 Inspection and warrant of fitness regime for cabinet heaters ... 72
5.2.6 Banning the sale or use of cabinet heaters ... 72
5.3 Summing up on options ... 73
6. Conclusions ... 75

Appendices

Appendix A References ... 76
Appendix B The Value of Statistical Life ... 82
Appendix C People consulted in this review ... 84

Figures

Figure 1 LPG sales in New Zealand ... 27
Figure 2 Natural gas and LPG prices ... 28

Tables

Table 1 Heating fuel use from the Census results 19

Table 2 Bottled gas heating across the regions 20

Table 3: Number of portable gas heaters supplied to the New Zealand market, 2004 to 2008. 21

Table 4 Comparison of home heating running costs 23

Table 5 Combined cost of space heating options for a given heating load 25

Table 6 Uptake of Warm Up New Zealand scheme 30

Table 7 Consumption of LPG in unflued heaters 31

Table 8 Social costs excluding property damage during 1993-2009 35

Table 9 Estimated cost of structure fires 36

Table 10 Number of accidents 38

Table 11 Estimated social cost savings for children up to 12 years 44

Table 12 Estimated social cost savings for children up to 12 years using NO_2 estimates 46

Table 13 Estimates of Social costs for 13-17 years assuming effects as in 0-12 years ... 47

Table 14 Estimates of Social costs for all children 48

Table 15 Comparative cost of LPG and electric heating 55

Table 16 Benefits and costs of cabinet heaters compared to alternative electric plug-in heaters 61

Table 17 Variation in benefit cost ratios with price and health cost estimates 62

Table 18 Summary of options 74

1. Introduction

The purpose of this review is to establish whether portable liquefied petroleum gas (LPG) cabinet heaters[1] provide a net benefit to New Zealand, or whether they remain a suitable means of heating in New Zealand in light of current knowledge of economic, health, social and environment factors. The review includes analysis of economic and social costs and benefits and risks relating to these factors to inform on the net social cost or net benefit from their use. This means defining a counter-factual, or presenting a comparison with different forms of heating that present the alternatives to portable LPG heaters to establish to what extent they are likely to improve on the existing situation.

1.1 Background

LPG cabinet heaters are unflued portable gas-fired space heaters that are designed for indoor use and incorporate a 9 kg liquefied petroleum gas (LPG) cylinder. Like all unflued gas space heaters, they discharge the products of combustion into the space in which they operate. They have never been approved for use in Australia and the United States, although they are allowed in the United Kingdom and other European jurisdictions. They first appeared in New Zealand in the late 1970s when the energy crisis focused attention on new uses for LPG which was produced as a by-product of oil and gas production.

Cabinet heaters are in widespread use in New Zealand, being cheap to purchase, portable, and independent of reticulated gas supply (and electricity). But their place as a heating option for New Zealanders has come under scrutiny on both safety and health grounds. Cabinet heaters are commonly perceived as less safe than other heating options. Health and environmental agencies in New Zealand have also been aware that the use of unflued gas heaters, including cabinet heaters, can have a detrimental effect on indoor air quality, which can in turn lead to adverse health effects. Because they are mobile it is hard to enforce guidelines on use (such as provision of adequate ventilation or air space to discharge into). There have also been questions around the reliability and safety of the connecting fittings between gas bottle and appliance.

The benefits of cabinet heaters come from the heating they provide and the convenience of portable units which do not require connection to a reticulation grid. The costs to society, apart from purchase of appliances and fuel, comes from these heaters' contribution to combustion emissions that affect indoor air quality and health, enhanced risk of fires and asphyxiation from faulty use or components, and increased moisture inside buildings associated with moulds and paint deterioration that increase building maintenance requirements.

[1] Throughout the rest of this report the term "cabinet heaters" refers to portable unflued LPG cabinet heaters which are the subject of this review, and not to any other form of heater.

This review is centred on a cost benefit analysis of the use of cabinet heaters in New Zealand. The review does not cover other LPG appliances such as outdoor patio heaters, barbecues or stoves for cooking, nor does it cover appliances that run on natural gas. Other types of indoor gas heater, both fixed unflued heaters and flued heaters, are out of scope of this review except to the extent they are considered as alternative heating options for comparison purposes.

1.2 Framework for analysis

A social cost benefit analysis of the use of cabinet heaters considers the net benefits obtained from use of these heaters after accounting for all the costs incurred in obtaining those benefits. Costs are generally valued at the opportunity cost of resources used up in affected activities; benefits are valued by people's willingness to pay for them. When considering the costs and benefits of an activity, it is necessary to consider the net effect against what would happen in the absence of that activity: in the case of cabinet heaters that are used to provide heat, this means considering their effects against the next most likely alternative heating choice if LPG cabinet heaters were not available, which may mean either people make do with less heat, or else obtain equivalent level of heat from alternative means.

The debate that has arisen over cabinet heaters illustrates a division in the way that their use is viewed, and on the emphases placed by different commentators in the debate. On the one hand there are the benefits of convenient, controllable heat which, to the extent that people continue to be willing to pay to use them, presumably exceed the readily apparent costs of purchasing and running the heaters. On the other hand there are less obvious costs and consequences of using the heaters, such as the risks of fire and impacts on indoor air quality that aggravate respiratory conditions for the occupants. These may be not fully appreciated by such heaters' users, and also detract from productive activity in ways that affect more than just the heaters' users: sick days off work or school disrupt the work of colleagues, and medical costs may be partly borne by the wider body of taxpayers, rather than those who expose themselves to the risk of using these heaters. There is a growing body of opinion that the unapparent costs are sufficient to justify the banning or regulation of the use of cabinet heaters. The cost benefit analysis at the centre of this review is intended to scope the problems that arise from these heaters, and whether they are so large as to outweigh the benefits of their use.

That people choose to use cabinet heaters indicates that they value their benefits and are willing to pay the apparent costs. But if those decisions do not take account of the unapparent costs, market choices could be distorted and may warrant some policy intervention to reduce the resulting social cost. The cost benefit framework being used to investigate this balance comprises:

- Benefits of use of cabinet heaters
  - The convenience of a source of readily controllable space heating for indoors, to counter the ill-effects of insufficient heat

  - Large output to rapidly heat the space around the heater
  - Portability and flexibility in where heat can be provided
  - Self-contained heating independent of reticulated gas or power supplies
  - Pre-purchased quantities of energy that may assist some with budgeting
- Costs of use of cabinet heaters
  - Users' costs in acquiring/purchasing the heaters
  - Users' costs in operating the heaters, comprising principally fuel and periodic maintenance
  - Costs of suppliers and delivery infrastructure that are not recovered through the prices that users pay (such as costs of accelerated capacity renewal brought about by changes in cabinet heater use but borne by non-cabinet heater users)
  - Costs to users and other building occupiers from risks of fires and asphyxiation associated with the use of these appliances
  - Costs to users and other building occupiers from effects of emissions on indoor air quality that can aggravate respiratory conditions like asthma and result in
    - Increased use of medications to control the conditions
    - Increased doctor's visits and other treatments to manage the conditions
    - Productivity losses from days off work or school
  - Costs to users and building owners from the effect of moisture given off by the combustion process, which may
    - Encourage growth of moulds, fungi and dust mites that aggravate respiratory conditions such as asthma
    - Increase costs for building maintenance, such as cleaning of moulds or repairing the effects of water build up on the structure of buildings
  - Loss of life quality for building occupants from continual exposure to the adverse air quality and dampness associated with uses of these heaters.

The size of these costs, relative to the benefits provided by these heaters, is what a social cost benefit analysis is intended to address. Ideally it would quantify the extent of use of these cabinet heaters in New Zealand, how they are used, where they are used and by whom, to identify how large the costs are likely to be and where they lie.

Such an analysis focuses on the end uses of the heaters and their effects on the economic surpluses of consumers and producers associated with their use. It assumes that the cost of inputs into the process of using these heaters reflects the full cost of resources used in the process: for instance the cost of fuel reflects the full cost of supplying fuel, and effects on the supply industries of fluctuating levels of gas use are not a societal cost unless there is a large and artificially imposed change in use that results in stranded assets and loss of future certainty for investments.

1.3 Outline of report

This report proceeds by first outlining views on the uses of cabinet heaters, referring to previous literature and consultation with a selection of interested parties; then compiling data to quantify the scale of the issues associated with the use of these heaters. It then considers the balance of costs and benefits, with due caveats on the limitations of available data, and concludes with a discussion of various options for addressing the issues raised in the review.

2. Current and previous views on cabinet heaters

There have been calls for the increased regulation or even banning of cabinet heaters since the early 1990s, based on the health and safety risks for those using them regularly, particularly in residential settings. But it has been difficult to assemble evidence to demonstrate the extent of these risks is sufficient to warrant such measures.

2.1 A brief history of cabinet heaters in New Zealand

LPG cabinet heaters first appeared in New Zealand in the late 1970s and early 1980s, their introduction arising from the twin pressures of the oil-based energy crises and the government's urge to relieve energy and balance of payments constraints by making more use of the relatively abundant domestic gas production that was then coming on stream. Soon after their introduction, safety concerns were raised over the connection between bottle and appliance, and in particular the use of screw thread couplings which created risk of gas leakage if not secured tightly. As a result, importers of cabinet heaters (sourced mostly from Europe at that time) moved to more secure clip-on couplings, and New Zealand manufacturers began making such couplings. In subsequent years, issues arose with those couplings (e.g. over the quality of rubber seals) and there have been further refinements to what is required for couplings to be approved for use in New Zealand.

From the outset New Zealand's policy towards cabinet heaters has diverged from that in Australia, which has not banned the use of unflued cabinet heaters, but rather never approved their use or importation. The reason for that non-approval was principally concerns over the risks of fire posed by having LPG bottles inside a building. Australia still allows the use of unflued heaters using piped natural gas or LPG fed from large bottles outside the building, including portable unflued heaters that are connected by hose with a bayonet fitting to piped gas outlets in the building. The emissions of combustion products and moisture from those unflued heaters are similar to those from unflued cabinet heaters so the health impacts of such heaters were not decisive in Australia's decision at that time, although they have subsequently attracted more attention (enHealth 2007). This divergence in policy means that there is no common development of policy or standards between the two countries with respect to cabinet heaters.

Cabinet heaters do not appear to have been introduced into the United States market, although this again appears to be due to market reasons rather than deliberate regulatory restraints. Unflued (or "unvented") gas heaters fixed to piped supplies are widely permitted across the states, and there has recently been a proposal to authorise unflued portable LPG heaters for use in the USA. That current proposal has reportedly stalled over the technical issue of whether the heaters would be used with steel bottles (as is currently the case in New Zealand) or with transparent composite bottles which have different properties when exposed to heat in the event of a fire.

We have not been able to confirm the regulatory status of cabinet heaters in Canada. However, several websites state that such heaters are available for indoor use in Canada which suggests there is no national prohibition of them.

A number of European countries, such as the UK, France and Italy, still permit the use of cabinet heaters and they are also used in Japan. We have not found evidence of a worldwide trend towards banning their sale or use. However, particularly in countries with cool temperate climates, the use of unflued gas heaters of all types looks increasingly at odds with the drive to better insulation and efficient heating for both energy security and environmental purposes. There have been moves to remove unflued gas heaters from public institutions such as schools and hospitals where scale suggests more efficient heating options ought to be feasible (e.g. in the state of Victoria), but the use of cabinet heaters in such situations is not known to be widespread in New Zealand.

2.2 Previous consideration of cabinet heaters in New Zealand

The Environmental Risk Management Authority (ERMA) commissioned an inquiry into use of LPG cylinders of less than 10 kg in indoor situations in New Zealand which was reported in 2004 (the Wakelin Report). This reviewed the safety incidents associated with domestic LPG appliances (not just cabinet heaters), and provided figures for fatalities, injuries and rough estimates of the stock of appliances from which to infer rates of incident. It suggested there were probably about 450,000 portable cabinet heaters in use in 2004 (across a housing stock of about 1.4 million), with fatality rate of 0.1 deaths per 100,000 LPG heating households per year, and an injury rate of 0.9 injuries per 100,000 LPG heating households. The report found the most common causes of such incidents (both fires and asphyxiation) were leakage caused by damaged valves and connections, exacerbated by there being 3 broad styles of connection which, although broadly compatible, can result in damage when cross-connecting between different types for refilling bottles with gas or fitting them to appliances. The report provided some broad comparisons of options for reducing the rate of incidents, from banning indoor LPG appliances to disseminating codes of best practice use, but there was no quantified comparison of these different options.

The Ministry for the Environment has been examining the use of cabinet heaters as part of its investigations into air quality and residential heating. Following an internal scoping report into indoor air quality in 2003, it commissioned and published a series of reports from consultants, including the Warm Homes Technical Reports on Home Heating Methods and Fuels (2005), Detailed Study of Heating Options in New Zealand (2005a) and Social Drivers (2005b). These note the incompatibility of unflued gas heating with energy efficiency and sustainability objectives at that time. The Ministry of Health has issued a pamphlet on *Unflued Gas Heaters and Your Health*, which is largely based on a similar Australian document.

A report prepared in Australia on the health effects of using unflued gas heaters of all types has been widely referred to by commentators in New Zealand (enHealth 2007). It noted that unflued gas heaters have become relatively more important as sources of indoor air pollution in Australia, with recent decline in cigarette smoking and indoor combustion of coal, and that in monitoring experiments the use of unflued gas heaters often leads to concentrations of pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2) and formaldehyde which exceed health-based standards. The available evidence cannot determine the effectiveness of measures such as increasing ventilation and maintaining heaters in keeping pollutant levels within health-based standards. There is evidence that exposure to unflued gas heaters increases respiratory symptoms and new asthma among children, but it found insufficient evidence on the effect of such heaters on the health of adults.

A health impact assessment of future electricity scenarios by the Parliamentary Commissioner for the Environment (PCE 2006) recommended phase out of the sale of unflued gas heaters in New Zealand and programmes to encourage existing users to replace them with safer and healthier heating devices. The specific evidence on which this recommendation is based is not apparent in the PCE's report.

Another report calling for the banning of all unflued gas heating was the *National Value Case for Sustainable Housing Innovation* issued by Beacon Pathway in 2007. This was just one of a number of measures proposed to improve the energy efficiency of the housing stock and improve the health of its inhabitants, and it provided estimates of the effects of packages of measures in reducing the amount and cost of energy used for home heating. Recognising that poorer households that rely on unflued gas heating would face difficulty in meeting the up-front cost of installing more efficient appliances, that report presented a range of options, including the offer of government financial assistance and tighter requirements on the state of buildings offered for rental.

A paper prepared in 2008 examined the heating and household factors that contribute to indoor NO_2 in almost 350 houses in New Zealand (Gillespie-Bennett et al 2008), and reported on the change in NO_2 levels from controlled changes to cleaner heating appliances in this sample. Homes using unflued gas heaters had more than three times the level of NO_2 in living rooms than homes without unflued gas heaters. In homes that used unflued gas heaters as their main heating, changes to heat pumps, flued gas heating or enclosed wood burners achieved 67% reduction in NO_2 levels in living rooms, compared to the corresponding homes with unflued gas heaters. This paper does not, however, translate this finding into the likely consequences for health and activity, such as differences in probability of days off work with and without the presence of unflued gas heaters.

Another paper based on the same heater change experiment (Howden-Chapman et al 2009) describes in more detail the change in energy use and emissions from different categories of housing in the sample. While this alludes to the compilation of a cost benefit analysis, no such analysis is yet publicly available.

A further paper from the same stable (Howden-Chapman et al 2008) on effects of improved home heating on asthma in community dwelling children found children in the intervention group that had non-polluting and more effective heaters installed had annually 1.8 fewer days off school, 0.4 fewer visits to a doctor for asthma and 0.25 fewer visits to a pharmacist for asthma, as well as other symptomatic changes such as less sleep disturbed by wheezing and less dry cough at night. Mean temperature in the living room increased by 1.1^{o}C. However, the new heaters did not significantly improve lung function.

There are well documented grounds for concerns on the health effects of unflued gas heaters. As for any combustion process, emissions from unflued gas heaters include a complex mix of contaminants including NO_2, CO, fine particulate and formaldehyde. In most instances NO_2 is the contaminant of most concern because concentrations regularly exceed air quality guidelines in homes with unflued heaters. Studies show that levels of NO_2 within homes using unflued gas heaters frequently exceed WHO ambient air quality guideline levels for NO_2 that are intended to protect health, raising the risk of adverse health effects particularly in vulnerable people including infants, children, asthmatics and people with respiratory illness. The updated WHO guideline (WHO, 2005) reviews epidemiological evidence from both indoor and outdoor studies for effects of NO_2. An Australian study (DEH, 2004) also measured exceedences of CO and formaldehyde guidelines in some homes with unflued heaters. Unflued gas heaters produce water vapour that adds to humidity that promotes the growth of mould, dust mites and bacteria, which can in turn cause health effects.

The above papers and findings are not specific to cabinet heaters, but they do point to associations of unflued gas heaters in general (both LPG and natural gas) with deteriorating indoor air quality that has adverse consequences for health. Combined with occasional but severe accidents which attract publicity, these have created a widespread public sentiment that the use of cabinet heaters presents a problem for New Zealand. In April 2009 *Consumer* magazine proposed such heaters be banned, on grounds that they are unhealthy, expensive and a fire risk. And in June 2009 *North and South* magazine picked up on an incident with a second hand cabinet heater to highlight issues around New Zealand's cold and under-heated houses.

2.2.1 The role of government agencies

Cabinet heaters sit on a boundary between different government agencies' statutory responsibilities. As LPG is a hazardous material, the Environmental Risk Management Authority (ERMA) has responsibility over LPG bottles, valves and connections, but no authority over the appliances themselves. Responsibility for appliances falls to The Ministry of Consumer Affairs (MCA) which has a generic role in overseeing the Consumer Guarantees Act and has the ability under the Fair Trading Act to order a safety ban on a specific product found to be unsafe. Energy Safety, now located within Ministry of Economic Development, has a role more specific to cabinet heaters in administering parts of the Gas Act to ensure the safety of consumer products which cover cabinet heaters. The Department of Building and

Housing (DBH) has no statutory responsibility over portable heaters as they are not fixtures to the building.

Other agencies with an interest in cabinet heaters are:

- Ministry of Health (MOH), which has the function of improving, promoting and protecting public health, in which role it has provided advice on the health risks of unflued gas heaters (including cabinet heaters)
- Ministry for the Environment (MfE), which has responsibility for air quality and administers national environmental standards for air quality in the outdoor environment
- Ministry of Social Development (MSD), which has interest in the affordability of home heating options and the avoidance of “energy hardship” among the more vulnerable members of society
- The Energy Efficiency and Conservation Authority (EECA) which has a policy to improve the energy efficiency and insulation of New Zealand buildings, and oversees current subsidy schemes such as Warm Up New Zealand
- The Housing Corporation of New Zealand (HCNZ), which manages the largest public sector housing stock in the country
- Regional councils, which have responsibility for air quality standards at the local level and also have interest in avoiding undue hardship in their regions.

Although the MOH, MfE and EECA in particular regard the continued use of cabinet heaters to be inconsistent with their remits and something to be discouraged, Energy Safety has no grounds for declaring the heaters unsafe: the rate of accidents (fire and CO poisonings) caused by these heaters, as recorded by Energy Safety, is not particularly high and there is no evidence that they are unsafe if used according to their manufacturers’ instructions, which now include:

- Use with adequate ventilation
- Servicing by a qualified agent at least once a year
- Leaving a metre between the heater and flammable materials
- Not placing flammable or chemical substances against it
- Not using it in bedrooms, bathrooms or other small spaces
- Not using it in a house where occupants have known respiratory conditions that could be aggravated by emissions.

All of these instructions depend on compliant behaviour by users which may be lacking, but that is not sufficient reason to declare these appliances unsafe under the current legislation and curtail their use, any more than it would be for other potentially lethal but otherwise useful if used properly consumer items, such as carving knives, baseball bats and motor vehicles. Whether it can be demonstrated that these appliances are so inherently risky in use to present a cost to the nation that exceeds their benefits is the question that this review and consultation addresses.

2.2.2 Regulation of unflued LPG gas heaters in New Zealand

LPG bottles, valves and connections are regulated by ERMA and there is a legal requirement for bottles to be tested at least once every 10 years. A dated stamp attached to the bottle is a pre-requisite for filling the bottle, and inspection of such certificates and application of simple soapy water tests to the valve seating on each refilling provides some means for regular checking of LPG bottles.

Gas regulations administered by Energy Safety (MED) require gas appliances to meet NZS5262 that specifies performance requirements relating to safety of the appliance. An appendix to that standard gives a number of ways of meeting these performance standards, in particular, by showing compliance with a number of relevant overseas standards, with some modification to allow for specific New Zealand characteristics (e.g. stability, or suitability for use with the mix of butane and propane used in New Zealand's LPG). A European standard EN449 is specific to unflued cabinet heaters and is one route to compliance. Although there is no Australian standard for cabinet heaters, compliance with Australian standards that comply with European directives can also be used to demonstrate compliance for NZS5262. Such reliance on overseas standards is common in New Zealand's regulatory systems in markets where local production is too small to warrant the development of a New Zealand specific standard (cf. motor vehicles).

There is also a compliance declaration regime that requires importers or manufacturers of unflued cabinet heaters to declare that they comply with one of the overseas standards consistent with NZS5262. This declaration is not an approval. It enables gas fitters or others to recognise these appliances as suitable for use in New Zealand. Gas regulations are currently undergoing review, and under changes to the declaration regime under the Gas (Safety and Measurement) Regulations 2010 that came into force on 4 May 2010, in future importers or manufacturers will have to demonstrate that the compliance of their appliances has been validated by an independent third party in a recognised Certification Assessment Body.

These standards do not require that advice on safe use or hazards be affixed to cabinet heaters. There is an Australian standard, AS4553 that could be read as applying to LPG cabinet heaters and which specifies labelling requirements. But as Australia does not have cabinet heaters it is unlikely that AS4553 was developed with cabinet heaters in mind and it may contain elements that are not readily applicable to cabinet heaters. Also, NZS 5262 cites another European standard (EN449) for cabinet heaters that arguably would not be necessary if AS 4553 was applicable. An agreement was reached between government and industry for a voluntary code of practice in presenting such advice, but this advice is generally included with the operating instructions of the appliance and is not affixed to the outside of the cabinet where it is likely to be regularly seen. In recent years the LPG Association, ERMA and Energy Safety have jointly funded publicity campaigns in the winter heating season, distributing through service stations leaflets and swing tickets listing safe practices to customers filling LPG bottles. There has also been since the Wakelin report improved training of forecourt attendants involved in dispensing LPG, giving attention to testing the bottles brought in for filling.

2.3 Consultation on use of cabinet heaters

As part of this review we have contacted a range of individuals and organisations with interest in the use of cabinet heaters. The purpose of this consultation was to identify and obtain any information those consulted might have from their experience with use of these heaters, and also to hear their ideas on what might be done to deal with issues associated with the heaters. There was a fair degree of convergence and overlap in what those consulted told us, and in the interests of succinctness we do not attempt to report here everything that everyone said, but rather to distil the themes that emerge. A full list of those who contributed to this consultation is included in an appendix to this report.

2.3.1 The benefits of cabinet heaters

While much of the previous literature (and indeed the current consultation) focused on the costs of using cabinet heaters, the fact that they continue to be used indicates that users do get some benefit from them. These benefits centre on:

- A source of heating that is convenient, instantaneous, easy to operate, has a large output capable of rapid heating and is available when and where it's wanted is a principal benefit
- Capability to be used over the greater part of the country where there is no gas reticulation
- Portability
  - within a property, reaching parts of buildings which other heating cannot reach
  - and from one property to another – useful for people who rent or move often
- Economic attractions in
  - obviating the need for gas installation costs, and for daily (non-energy) charges
  - aiding budgetary control through the prepayment of fixed quantities of energy, avoiding the "bill shock" that comes from reticulated energy services
- Security of heating supply, through
  - a useful alternative or back-up energy source in case of power outages
  - reducing the risk of complete heat loss during outages/power cut-off
- Environmental emission effects are recognised but can be managed and are not perceived as worse than alternatives such as wood or coal burning.

These benefits are widely acknowledged, including by representatives of the elderly (New Zealand Council of Elders), which is one part of the community commonly portrayed as vulnerable and at risk from use of these appliances. The dangers and costs associated with these appliances and their environmental effects are also recognised, but so too is the risk that if their sale is banned, the only models left in use will be old ones, which will pose increasingly greater risks as the availability of spares for maintenance dries up.

It has been suggested that despite their drawbacks, cabinet heaters have a role in providing an option for "customised solutions" to particular heating needs, for instance in old draughty houses in rural areas with elderly residents for whom likely alternatives like efficient wood burners are hard to manage (Melhuish). Draughts lessen the air quality impacts of these heaters, and while keeping houses healthy is hardly a sustainable solution, it needs to be recognised that in some houses or parts of houses it is hard to insulate and upgrade the heating, and that removing cabinet heaters would be reducing feasible heating options for such cases.

The benefits identified for cabinet heaters are widely thought to make them likely to be particularly attractive to:

- those on low or fixed incomes who are more susceptible to "bill shock";
- those with limited access to reliable alternative fuel supplies and heating solutions;
- those in rental property who can take the heaters with them and overcome the landlord and tenant impasse in which tenants have little incentive to invest in improved heating which is fixed to the property, but landlords have little incentive to improve heating because they do not pay the energy bills.

However, Census data finds bottled gas heaters are used by people across a range of incomes and they are not disproportionately the preserve of those on low incomes.

Those who see the availability of cabinet heaters as net beneficial are not in favour of their banning. While it is recognised they may not be recommended as the best choice for main heating source, they have a range of uses as supplementary or back-up heaters in situations where there are no close substitutes, so that restrictions on sale or use would represent a significant reduction in choice and options. If there are major problems with their use, it is product design and consumer education that need to be addressed, not the availability of appliances.

Respondents from the LPG supply industry maintain there is no consensus from studies on whether emissions from an unflued gas heater that is operating as it should and is being used in accordance with manufacturer's instructions does result in significant adverse health effects.

2.3.2 The risks and costs of cabinet heaters

Most of those consulted in this review tended to focus more on the risks and costs of cabinet heaters than on their benefits. Much of this stemmed from concern for the more vulnerable members of the community, who face extra exposure to risks of these heaters and lack the wherewithal to obtain less risky or more efficient heating alternatives. The reliance on these types of heater was commonly associated with those on low incomes, in rental property, the elderly and those with young children who may be susceptible to the effects of emissions.

a) Cost of operation

Many respondents challenged what they regarded as a widely held perception that LPG is a cheap form of heating, citing comparative cost estimates on the websites of Consumer magazine, EECA (less frequently) and Ministry for the Environment (least frequently). Many respondents noted that a low purchase cost and high running cost would contribute to the appeal of cabinet heaters, while locking in purchasers to higher cost and less efficient heating. They also suggested that many users would be inclined to forgo regular maintenance inspections by qualified service agents as the inspection cost was relatively high compared to the cost of a new heater (about a third), preferring instead to use the heater until problems arise and then replace with a new model. This would increase likelihood of heaters malfunctioning with associated increased risk of fire or CO poisoning.

Some respondents noted that although cabinet heaters have a power output (3.5-5 kW) that is higher than the maximum for individual electric resistance heaters (2.4 kW), it would be possible to get two or more electric heaters with equivalent power output for a similar price as a cabinet heater and gas bottle. Combinations of different types of electric heater would offer greater flexibility in use than a single cabinet heater, although the heat might be regarded as of different quality than the radiant heat from a gas flame.

b) Safety (fire and CO poisoning risk)

Regarding the risks posed by these heaters of fire and CO poisoning, respondents from the public health sector painted a rather bleaker picture than the records held by Energy Safety. In one district health board alone it was suggested that there would be about one case of CO poisoning admitted to hospital a year, which if applicable across the country would imply a much higher rate of such incidents than those notified to Energy Safety: 3 incidents attributable to this cause, involving one fatality and 6 non-fatal casualties, have been recorded in 17 years. The exact number of hospital admissions for CO poisoning could be extracted from health board records but this would take more time and resources than are available for completion of this current review. The respondents' recollection may be inflated by inclusion of CO incidents caused by other sorts of appliance or causes (e.g. motor vehicles), so even if extracted, admission records may not be traceable back to LPG cabinet heaters.

Dangerous levels of CO should only be emitted if a cabinet heater is malfunctioning in some way, and causing incomplete burning of gas. Respondents suggested this was quite possible given the low frequency of maintenance and servicing of cabinet heaters. A workshop engaged in such servicing suggested that one service check every two years was the most frequent return interval, very few in its district would be serviced annually and many might be serviced much less frequently, if at all.

Another possible source of CO malfunctioning was identified by a laboratory that has examined a number of cabinet heaters following incidents. This arises from design characteristics of some of the more recent models being sourced from China, in which a combination of gas injectors that are too large, misaligned or inadequately separated from the pilot light on the front of the heater, leaves them susceptible to "light back" in which a flame can occur around the injectors. Although this flame is contained within the cabinet and does not increase the fire risk, it can char the burners in the heater and also create CO, which is all the more dangerous because it comes from a heater which, from the front, would appear to be working correctly.

Beacon Pathway's analysis of Fire Service data show a statistically significant difference between the number of incidences per 100,000 portable LPG heaters which is 6.2, and the corresponding figures for electric heaters which is 2.3 on average for the period 2001 to 2009. Fire Service data do not distinguish between cabinet heaters and other LPG heaters such as patio heaters; nor does their recording of an LPG heater present at an incident indicate that it is necessarily the cause of the incident, so the incident rate for cabinet heaters is likely to be lower than 6.2. Conversely, the category of electric heaters covers a wide range of appliances, some (such as radiant electric strip heaters) have higher fire risk than others (storage heaters, heat pumps), so the incident rate for electric heaters that are most likely alternatives to cabinet heaters may well be higher than 2.3. While it is likely that portable LPG cabinet heaters are a greater fire risk than electric heaters, by how much is indeterminate from the currently available data.

c) Chronic health effects (risk of exacerbated ill health)

Many of the those consulted were concerned about the potential long term and chronic health impacts of the use of unflued LPG heaters, coupled with concerns for those vulnerable to the effects of heater use, and the belief that many of them lack the financial wherewithal and the knowledge to make better heating choices. There were common references to the young, the elderly, those on low incomes and those in rental properties, and how combinations of these characteristics exacerbate the problems for those who rely on cabinet heaters. For instance, it was suggested those renting and with low incomes face both low quality in the available rental housing stock, but also security concerns around crime that could make them less likely to open windows and achieve adequate ventilation for using unflued heaters.

Many were familiar with the risks of NO_2 in exacerbating respiratory conditions, and also of the health effects of moulds and mildews due to excess moisture from use of unflued gas heaters. However, good information about cost, associated health risks or problems with dampness and condensation was recognised as lacking or difficult to access. Many referred to the work done at the Otago Medical School, EECA and Consumer magazine as proving that cabinet heaters were neither safe to use nor as cheap to run as commonly considered.

There was a strong link made, explicitly or implicitly, with the association between unflued LPG gas heaters and households with low incomes and in rental accommodation, with limited options for improving their heating arrangements. Some viewed the use of unflued LPG gas heaters as a symptom of a wider systemic issue with the affordability and quality of housing, and implied the solution to their use was part of a wider approach for addressing that wider issue.

d) Moisture generation (risk of property damage and ill health)

The association of cabinet heaters with moisture generation in indoor environments was well known, as exemplified by condensation, mildew and moulds with adverse effects on both health and the fabric and structure of buildings. Some also pointed to the increased heating load required to heat indoor air with higher humidity, and raised the necessity of using a dehumidifier to neutralise this effect. One respondent suggested an unflued LPG heater produces 0.5 litres of water per hour, exacerbating a generic problem with New Zealand's old and cold housing stock, in which around 40% of houses exhibit some dampness problems (Beacon Pathway). Houses with an unflued LPG heater are statistically more likely to have a dehumidifier than those without, and as these cost $0.14-$0.42 per litre of water removed, they create an additional hidden cost to the cabinet heater user.

Some respondents mentioned the practice of landlords banning the use of LPG cabinet heaters through specific clauses in their tenancy agreements. However, others suggested that according to legal advice they had received, this practice would be unlikely to be enforceable if taken to court: such a clause would only be legally enforceable as protection against actual harm or injury, but as cabinet heaters are not unsafe if used as their manufacturers intend, such a clause would have no legal bite until damage could be shown to have occurred. Such legal advice may be debatable but has deterred HCNZ from using such clauses in its tenancy agreements, although other landlords may follow this practice until legally challenged. This means that although HCNZ has a policy of not fitting unflued gas heaters in its large housing stock, and of removing them as maintenance programmes allow, it exercises no control over the use of cabinet heaters by its tenants.

2.3.3 Suggestions for addressing problems with cabinet heaters

a) Barriers to addressing problems with cabinet heaters

The issue of budget control through pre-payment of fuel was a commonly cited reason why those on low incomes might prefer cabinet heaters, and a barrier to switching to other more benign forms of heating. While Power Manager devices can provide good real-time feedback on electricity use, the cost of using them is a deterrent to their more widespread adoption.

Several commented on limited knowledge on the relative cost and benefits of different types of heating, and of lack of knowledge of where to obtain information, despite comparative information being available on the websites of EECA, MfE and the Consumer NZ. Some commented that even budget advisers for those at risk seemed unaware of where to obtain this information, and were even recommending unflued LPG heaters.

b) Proposed solutions for problems with cabinet heaters

The most frequent proposed solution for problems with cabinet heaters was the banning of their sale and withdrawal from use. Many respondents recognised the need for replacement heating options to be available, but there was no consensus on how this would be achieved.

The Royal New Zealand Plunket Society adopted a remit in 2009 to pursue law changes to make illegal the use of unflued gas heaters in the home. This is based on concerns raised by its council members rather than any direct information on the adverse effects of these heaters on families with newborns. With more time and resources than is available for this review, such information could be collected.

Consumer NZ has also called for a ban on sale of cabinet heaters, on grounds that they are an expensive and risky form of space heating. They also referred to a Canadian requirement for CO monitors to be fitted to such heaters and linked to a cut-off device if the CO level gets too high. The use of CO monitors was also suggested by HCNZ as a means of making users more aware of this risk.

Others proposing actively discouraging or moving towards a ban on cabinet heaters include Beacon Pathway, Tenants Protection Society, EECA, MfE, MOH and public health organisations. The Warehouse Group has expressed a preference for New Zealand to move towards an outright ban of the use of LPG cabinet heaters, because of the dangers associated with use of a naked flame in proximity to a large energy store and the health implications of use with inadequate ventilation, and it has suggested a clearer regulatory framework than at present covering both new product and the second hand market for the transition period.

Some of those consulted assembled statistics to inform this review. For instance, Community Energy Action in Christchurch extracted data from the 2001 census to show that in their district 4% of households had access to only bottled gas for heating, 16% had access to bottled gas and electricity, and a further 11% had other combinations of fuel source including bottled gas. Further noting from the Household Energy End-Use Project (HEEP) study that houses heated by LPG cabinet heaters tend to be colder on average than those that use most other heating options (other than just electric resistance heaters) they propose targeting the small proportion of households reliant on cabinet heaters for an orderly phase out of such heaters, through an integrated package of information, advice and financial support.

Many respondents noted the likely need for financial assistance to encourage replacement of unflued LPG heaters with cleaner more efficient heating sources. However, clean heat subsidy schemes have generally been aimed at improving the housing stock rather than rewarding individuals, and do not overcome the reluctance of individuals to invest in fixed heating systems if they may move before they see the full return on their investment. Overcoming that may require a higher rate of assistance than has hitherto been the case.

Some respondents alluded to problems with the Residential Tenancies Act and suggested tighter interpretation of what is regarded as a fit condition for renting. At present there is no requirement to provide heating in a property other than access to a power socket, and there were suggestions around developing standards for space heating in rental properties, or requirements to provide installed space heaters as there are for provision of a stove for cooking and hot water capability.

There were also suggestions around better communication of information about the use of cabinet heaters, both with respect to comparative costs against those of other heaters and with respect to recommendations for safe use. This might involve requiring attachment to heaters in a visible location of a label with the 5 or so points for safe use (as currently found on the LPGA website), in multi-lingual versions or with readily comprehensible pictograms. There were also concerns that such information should be visible at point of sale to better inform the purchase decision.

2.4 Summing up

The consultation revealed a high degree of convergence on the issues around the uses of cabinet heaters, but a high degree of divergence on the relative weight placed on different perspectives on them. Those with a high concern for public health and safety and environmental quality generally want to see their use substantially curtailed, whereas others place more emphasis on their role in adding to the options and choices available for tailoring heating solutions to particular circumstances.

A number of those consulted expressed a preference to see the use and sale of such cabinet heaters to be banned in New Zealand, including Community Energy Action, Plunket Society, Tenants Protection Association, Beacon Pathway, Consumer NZ, Ministry for the Environment and EECA. Some were opposed to banning, including the Asthma Foundation and the New Zealand Council of Elders, preferring instead to see better information and education on safe and appropriate use of such heaters.

Two items which received little mention in the consultation were:

- Use of cabinet heaters outside the home, in restaurants, workshops and institutional settings like community halls, schools and hospitals. While there was some mention of their incompatibility with school and hospital use, we received virtually no comment on their use in other settings, or the implications of banning their sale or use on settings other than residential.
- Contribution of cabinet heaters to greenhouse gas emissions was also scarcely mentioned. Under the emissions trading scheme, suppliers of LPG will be responsible for acquiring emission units to match the emissions from their product and can be expected to add this to the price they charge for LPG, so the effect will be internalised and left to the market to resolve how much greenhouse gas people are willing to pay to emit through use of LPG.

That cabinet heaters are portable and difficult to monitor complicates regulation of their use, but they are not alone as potentially risky items that nevertheless can be used safely and beneficially by most of those who use them. Regulators face a two fold problem in determining whether the problems posed by these heaters are significant enough to warrant intervention, and if so how best to address their adverse effects without depriving people of the benefits that they provide. The next sections of this review address these questions.

3. Current uses of cabinet heaters in New Zealand

In order to estimate the costs and benefits of cabinet heaters in New Zealand it is necessary to identify how many of them there, how they are used, and what contribution they make to heating and energy consumption in New Zealand.

3.1 How many cabinet heaters are there?

There is no authoritative record of the number of cabinet heaters in New Zealand. While estimates can be drawn from the numbers of cabinet heaters imported or sold in the New Zealand market, there is no information on the rate at which these heaters are scrapped. Point estimates of the stock of bottled gas or portable heaters in residential housing are available from the Census and the Household Economic Survey, but these do not distinguish cabinet heaters from other types or cover the use of heaters in commercial and industrial premises such as workshops and restaurants. The different sources appear to conflict in detail, so all estimates of the extent of unflued LPG cabinet heater use need to be treated as approximate.

The 2004 Wakelin Report for ERMA estimated the total stock of cabinet heaters to be around 450,000, and other sources state figures that range from around 400,000 to over 500,000. Not all of these heaters will be used in residential dwellings e.g. some may be used in restaurants, workshops or temporary accommodation like baches.

In its detailed study of heating options in New Zealand (MfE 2005b), the Ministry for the Environment estimated the number of homes that had portable gas heaters as an available option had risen from 25,000 (2% of households) in 1985/86 to 506,900 in 2003/04 (34% of households). This increase is equivalent to an average annual percent change of 18% over the 18 year period. That report identified cabinet heaters as replacing unflued kerosene heaters and also moving into the market areas occupied by electric plug-in heaters. It estimated such portable heaters were the only heating method in 71,000 households (5% of total), and most such heaters were used for spot heating or emergency use in conjunction with other heating sources such as wood burners and electricity (MfE 2005b, p13).

MfE (2005) also identified from a telephone survey that 24% of households across New Zealand reported having unflued gas heaters in their main living area, with higher proportions reported in Hamilton, Gisborne and Nelson.[2] This placed it behind wood (52%) and electricity (57%) but ahead of flued gas (9%). The description "unflued gas heaters" is not wholly attributable to cabinet heaters, as responses would also cover unflued natural gas heaters rather than LPG cabinet heaters, or unflued heaters attached to piped systems fed by large LPG bottles.

The MfE's figures draw on Statistics New Zealand's *Household Economic Survey,* which identifies portable gas heaters by tenure of dwelling. According to the Survey

[2] Based on a sample of 201 households with a sample error of 6.9%.

in 2003-04 portable heaters were found in 31% of rental properties, 38% of dwellings owned with a mortgage and 27% of dwellings owned mortgage-free, suggestive of a lower use among older or more financially secure home owners. The category description “portable gas heater” is likely to include a wide range of appliances such as patio heaters or portable heaters with a bayonet fitting to fixed piped systems, so the Survey’s and MfE’s figures are likely to overstate the number of cabinet heaters.

Table 1 shows recent New Zealand Census results on uses of fuel for heating in New Zealand dwellings. This shows that in 2006 there were 388,746 dwellings recording bottled gas as a form of heating, 26% of the total dwellings at that date. Bottled gas may include LPG sold in 45kg bottles and fixed to the outside of houses and piped to fixed indoor heaters, both flued and unflued: the number of such fixed bottle dwellings is unknown but is commonly considered to be low (Fryer et al 2006) and more recently has been estimated to be around 3,500 (Wilton and Baynes 2009).

Table 1 Heating fuel use from the Census results

	Total responses					
	1996	**2001**	**2006**	**1996**	**2001**	**2006**
Electricity	948,363	937,719	1,050,095	*74.3%*	*69.0%*	*71.4%*
Mains gas	142,704	175,419	185,826	*11.2%*	*12.9%*	*12.6%*
Bottled gas	273,927	368,118	388,746	***21.5%***	***27.1%***	***26.4%***
Wood	598,605	582,267	574,485	*46.9%*	*42.8%*	*39.0%*
Coal	159,537	121,170	98,226	*12.5%*	*8.9%*	*6.7%*
Solar Power	8,913	12,318	15,159	*0.7%*	*0.9%*	*1.0%*
Other Fuels	11,541	14,130	29,304	*0.9%*	*1.0%*	*2.0%*
No fuels used in dwelling	23,343	36,207	33,177	*1.8%*	*2.7%*	*2.3%*
Not elsewhere included	47,982	57,126	66,189	*3.8%*	*4.2%*	*4.5%*
Total dwellings	**1,276,332**	**1,359,843**	**1,471,746**	*100.0%*	*100.0%*	*100.0%*

Source: NZIER from Statistics New Zealand 2006 Census data

The LPG Association, however, suggests there are around 100,000 piped LPG systems supplied by twin-packs of 45kg bottles, no more than 10% of which would be in non-residential premises such as hotels and workshops. Some of these may be for cooking or hot water only, but most are likely to have space heating appliances as well and need to be deducted from the Census figures for bottled gas heating. Assuming piped LPG systems have grown at the same rate as growth in 45kg LPG sales (see section 3.3.below) 90,000 residential systems at the start of 2009 would equate to around 78,700 in 2006.

So homes with cabinet heaters account for most of the Census result, and such heaters were likely to have been found in around 310,000 homes, 21% of total households nationwide, in 2006. If cabinet heaters had declined at the same rate as 9kg bottle sales from service stations, the number of households with cabinet heaters would have dropped by about a third since then to around 210,000. However, this would be a very large drop in a short period. It is less likely that cabinet heaters have been discarded on that scale than that households are using them less or have “retired” them to the spare room for occasional use. This suggests they are still likely to be found in around 300,000 or more households across New Zealand.

Aside from the absolute numbers, the Census results suggest that the number of dwellings reporting bottled gas heating has increased by an annual average rate of 3.6% per year over the period 1996 to 2006. This is over twice the average annual rate of growth in total dwellings (1.4%). The number using bottled gas dropped from 1996-2001 and rose again from 2001 to 2006, possibly reflecting uncertainty caused by two dry year energy conservation campaigns in the winters of 2001 and 2003.

Table 2 shows findings from the 2006 Census on the frequency of bottled gas used for heating dwellings across the regions of New Zealand, and the percentage share of dwellings in each region. Regions where the percentage share is greater than the national average are shown in bold type and are mostly in the North Island, particularly outside the metropolitan centres. The two South Island regions with higher than average share of bottled gas, Canterbury and Nelson, may reflect air quality issues and associated controls on solid fuel burners in those regions' main urban centres.

Table 2 Bottled gas heating across the regions

	Bottled gas	Total dwellings	LPG use in regions
Northland	16,776	55,524	***30.2%***
Auckland	105,201	437,988	*24.0%*
Waikato	42,177	140,268	***30.1%***
Bay of Plenty	33,195	96,165	***34.5%***
Gisborne	5,637	15,663	***36.0%***
Hawkes Bay	20,946	55,224	***37.9%***
Taranaki	9,267	40,281	*23.0%*
Manawatu-Wanganui	22,971	84,768	***27.1%***
Wellington	36,036	168,849	*21.3%*
Marlborough	4,179	16,842	*24.8%*
Nelson	5,064	17,187	***29.5%***
Tasman	4,293	17,271	*24.9%*
West Coast	3,018	12,768	*23.6%*
Canterbury	56,244	201,660	***27.9%***
Otago	16,320	75,231	*21.7%*
Southand	7,347	35,802	*20.5%*
Area outside regions	72	249	***28.9%***
	388,746	**1,471,746**	*26.4%*

Source: NZIER from Statistics New Zealand 2006 Census data

Wilton and Baynes (2009) report on a further survey of heating in 1,200 households to update and compare with the MfE's 2005 survey. This suggests that the number of houses with bottled gas heating in the main living area was 292,367 in 2005, but had fallen to 127,120 by 2008, a drop attributed by the authors largely to increases in the price of LPG over this period. This would be equivalent to the use of bottled LPG for main living area heating dropping from 20% to 8% of households over the four year period (inclusive).[3] Nevertheless, houses using bottled gas still far outnumber those

[3] These percentages are lower than in the MfE study because they pertain to heaters that are both unflued and from bottled gas, and will predominantly refer to cabinet heaters. Wilton and Baynes'

using reticulated mains natural gas, which is confined to North Island localities along the main gas pipelines. Table 4.4 in Wilton and Baynes (2009) shows the number of houses with unflued bottled gas in 2008 still exceeded those with flued bottled gas (i.e. piped systems fed by 45 kg LPG bottles) and those with mains gas. So it is likely that cabinet heaters are one of the most, if not the most, numerous type of gas appliances in New Zealand, which makes them, other things held equal, also the most likely to be associated with reported incidents.

Table 3 shows the number of portable gas heaters supplied to the New Zealand market over a five year period (sourced from Wilton and Baynes 2009). The new heaters entering the market averaged 45,100 per year over the 2004-2008 period, which would be consistent with 10% replacement per year, assuming an average life of 10 years for these heaters. This would imply a total stock of around 450,000, as in the Wakelin Report (2004).

Table 3: Number of portable gas heaters supplied to the New Zealand market, 2004 to 2008.

Sales data

Year	Total
2004	35,575
2005	47,522
2006	48,131
2007	60,546
2008	36,775

Source: Wilton & Baynes (2009) from LPGA data

From the foregoing therefore it is likely that:

- The total stock of cabinet heaters is in the region of 450,000 to 500,000, making them probably the most numerous gas appliance in New Zealand and the most likely to be associated with incidents
- They are found in around 310,000 homes (ca 21% of total households) in the 2006 Census, although this may have dropped since then, and some homes may have more than one
- Around 2/3 of homes with cabinet heaters have had them in the main living area, but this number appears to have declined in recent years, probably in response to rises in LPG prices and developments such as the increased market penetration of alternative heating options such as heat pumps.

3.2 How are cabinet heaters typically used?

As with the number of cabinet heaters, there is also uncertainty and conflicting evidence among sources on how they are typically being used.

estimate for all unflued heaters (bottled and mains gas) in 2005 is 24%, the same as that in the MfE's 2005 report.

The Home Energy Efficiency Programme (HEEP) conducted by BRANZ has undertaken detailed investigation of energy types and uses for a sample of 500 houses. Spanning several years, in this programme 38% of sampled houses have had portable LPG heaters (BRANZ 2004). Scaling up the HEEP proportions across the New Zealand housing stock implies around 500,000 LPG cabinet heaters in households. Over 40% of the heaters are used for less than five hours per week during winter, with half of the heaters spending 90% of their time on one setting (two thirds of which are on the lowest or economy setting). Dehumidifiers were found in 31% of the houses that had LPG cabinet heaters, compared to 22% of houses without cabinet heaters, suggesting the association of moisture with LPG use is well recognized by these heaters' users.

Across the HEEP sample, annual average gross energy use per house is estimated to be 11,410 kWh, of which 240 kWh (2%) is from LPG (BRANZ 2006). For space heating only, the annual gross energy use across the sample is 3,820 kWh, of which LPG's 240 kWh is 6%. As the penetration of LPG heaters into the sample is far greater than the share of LPG in energy use, it could be inferred from the HEEP analysis that cabinet heaters are, on average, not used much and are predominantly a form of supplementary rather than primary heating source.

A different picture emerges from a qualitative consumer survey of users of LPG cabinet heaters (Fryer et al 2006). This found that almost half of survey respondents (43%) regarded the unflued LPG cabinet heater to be their main heating source: as the survey was only of LPG cabinet heater users, however, it may have picked up more committed users than the HEEP study. Most (91%) had only one cabinet heater but over half had a heater that was at least five years old. The survey found that cabinet heaters were perceived as a quicker and cheaper form of heating than other heating sources by over 40% of users, and were used quite frequently. Just over 70% of users ensured some form of ventilation in the room when using their unflued heaters, but over a third (38%) of users admitted that their cabinet heater had never been checked by a qualified service agent. Most knew many of the safe use recommendations, but many could not recall from where they had obtained them.

MfE (2005b) also found that houses heated by cabinet heaters had the second lowest indoor air temperatures of all heating options – a winter living room temperature of 16.8^{o}C compared to 16.4^{o}C for portable electric heaters, 17.7^{o}C for fixed gas and 18.2^{o}C for solid fuel heaters. These sources are now rather old and their findings may have been overtaken by recent developments, like the increased market penetration of heat pumps and changes in LPG price which are likely to have reduced reliance on cabinet heaters as a primary home heating source.

3.3 The cost of unflued LPG cabinet heating

3.3.1 Operating costs

Cabinet heaters are commonly perceived to be a cheap form of heating, but while this may once have been the case it no longer appears to be so. A 9 kg bottle can burn for around 115 hours at 1 kW output, or as little as 23 hours at 5 kW output, and may last a couple of weeks in everyday use. The cost of refilling at forecourts has risen in recent years from around $21 to $32-$35 depending on location so the cost of heat output from such heaters has increased accordingly.

The Centre for Applied Engineering (2007) estimated the cost of heating a defined space to a specified level through 10 different heating options, the results of which are summarised in Table 4. This showed that in general unflued gas heaters were less costly to run than their flued gas counterparts, but that unflued LPG heaters, although less costly than plug-in electric resistance heaters, were nevertheless more costly than most other alternatives, including flued natural gas, solid fuel burners and electric heat pumps. In April 2009, Consumer magazine declared unflued LPG heating to be the most costly of 7 heating types, at around 30 c/kWh, reflecting the increase in LPG prices. In June 2009 EECA issued its comparative estimates of the cost of heating in which unflued LPG heating was estimated to be around 40.5 c/kWh, on the assumption that 30% of energy would be lost by the requirement to open a window to allow adequate ventilation of the unflued heater.

Table 4 Comparison of home heating running costs

Consumer prices, GST inclusive

	CAE Nov-07 *c/kWh*	**Consumer Apr-09** *c/kWh*	**EECA Jun-09** *c/kWh*
LPG Flued	22.5	19.5	22.0
Electric resistance heaters	20.2	24.0	24.0
LPG Unflued	18.8	30.0	40.5
Natural gas flued	13.5	15.0	18.0
Natural gas unflued	11.3	na	23.5
Wood pellets	11.5	14.0	12.0
Coal	8.8	na	na
Wood	8.6	10.5	11.0
Electric Heat Pump CoP 2.5	8.0	9.0	7.0
Electric Heat Pump CoP 3.0	6.7		6.0

Source: NZIER using data from CAE 2007, Consumer 2009, EECA 2009

The Consumer and EECA figures are not identical but are broadly comparable.[4] The veracity of the 30% heat loss assumption used by EECA is open to question: clearly some heat will be lost by opening a window and the heating efficiency of unflued LPG

[4] General product LPG has a net calorific value of 45.66 MJ/kg (MED EDF 2009), which equates to 0.079 kg/kWh assuming 100% combustion efficiency. A 9kg bottle refill of $32 ($3.56/kg) would mean 28.1 c/kWh; at $35 per refill ($3.89/kg) it costs 30.7 c/kWh. Flued gas heaters lose around 11% of their combustion energy in flued exhaust gases (University of Otago 2009) so a flued LPG heater would burn 0.089 kg per kWh which, at $2.50 per kg in large bottles, would equate to 22 c/kWh. On this basis EECA's cost estimates (removing the 30% energy loss adjustment) are equivalent to $3.60/kg (28.4 c/kWh) for 9 kg bottles and $2.50/kg for 45 kg bottles; those of Consumer imply higher cost ($3.80/kg) for 9 kg bottles and lower cost ($2.20/kg) for 45 kg bottles.

heaters has been claimed by different sources to be between 60-70% and more than 90%. But organisations such as EECA and the Consumer NZ which have a policy of discouraging the use of unflued heaters do not test them for the efficiency of output, so the actual energy losses from their proper use are not known.

In addition to fuel costs the cost of maintaining cabinet heaters can be substantial, relative to the cost of purchasing a heater. An inspection by a qualified servicing agent costs around $45 (including GST), excluding any parts for replacement. Energy Safety recommends such servicing be done once a year, but both the consumer survey of users (Fryer et al 2006) and feedback from consultation suggest these appliances are professionally checked much less frequently: industry respondents suggest once every two years is a more likely modal frequency of inspection and many appliances are likely to be inspected less frequently, if at all.

3.3.2 Capital costs of cabinet heaters

When cabinet heaters first entered the New Zealand market in the late 1970s and 1980s they were sourced from mostly European manufacturers and priced relatively highly. Through the 1990s such heaters typically cost between around $300 and $500, depending on their features, and these early models are believed to have been relatively robust, with an average useable life-span of around 10 years (Wakelin 2004). More recently the source of such heaters has shifted to Chinese and other Asian manufacturers (even when European branded) and the price of a new cabinet heater has dropped to somewhere in the range of $120-$150 (GST inclusive) for basic models, with a useable life-span that has yet to be determined. Higher priced models of around $400-$500 are still available, generally incorporating additional features such as electric fans to distribute heat.

In addition, purchasers of cabinet heaters also need to buy a 9 kg gas bottle, new ones of which retail for around $45 including GST. This would bring the total acquisition cost of a mid-price range basic model to about $180 per heater, although some people may use a new heater with a bottle they already own, recycled from some other appliance like a barbecue or camping stove. At such a price, a cabinet heater is less costly to acquire, by a factor of 10 or more, than any of the cleaner heating alternatives (such as heat pump, wood stove or flued gas heater).[5] Electric resistance heaters, including radiant strips, fan heaters, oil filled column heaters and convection heaters, are less expensive to acquire but limited to a maximum 2.4 kW output so as not to overload the safety limits on residential circuits. Cabinet heaters have a power output substantially greater than this, of between 3.5 and 5 kW. For the price of an unflued LPG cabinet heater and bottle it would be possible to buy two electric heaters with a similar combined output, although with such a combination it would still be difficult to replicate the rapid heat boost of the larger gas heater.

[5] Although LPG cabinet heaters may be considered cleaner burning than wood stoves because they do not produce particulates, the term "clean heat" is used here in the same sense as in the clean heat programmes of EECA and Environment Canterbury to include wood burners that comply with emission standards, flued gas and electric heaters but exclude unflued gas heaters.

3.3.3 Combined costs of space heating appliances

To give an indication of the combined costs of space heating appliances, Table 5 presents the results of running costs and annualised purchase costs of a range of representative heating appliances. These figures are intended to be representative of purchase, installation and operational costs of "typical" models of each appliance, but do not claim to be statistical averages of their types. The expected lifetime of appliances is standardised at 15 years, except for wood and coal (multi-fuel) burners which are a little longer, and unflued LPG and electric resistance heaters, which are shorter.[6] The annualised cost of purchase is calculated with a 3% discount rate, based on the post-tax interest income forgone on current bank deposits, as representative of the opportunity cost of a private householder. The annual fuel cost is calculated for a standard load of 950 kWh – not the full cost of heating the average house – and using the costs per kWh from EECA (2009) with the exception of coal. For illustrative purposes EECA's estimated costs of unflued heating have been adjusted to remove the 30% assumed energy loss for opening a window.

Table 5 Combined cost of space heating options for a given heating load

Consumer prices (GST inclusive)

	Purchase cost $	Expected lifeyears	c/kWh	Annualised cost $/yr	Annual load kWh	Annual fuel $	Total cost $/yr
Natural gas unflued	1,000	15	16.5	$83.77	950	$156.75	$240.52
Electric resistance heaters	100	7.5	24.0	$15.09	950	$228.00	$243.09
LPG Unflued	180	10	28.4	$21.10	950	$269.80	$290.90
Coal	3,000	20	9.5	$201.65	950	$90.25	$291.90
Electric Heat Pump CoP 2.5	2,750	15	7.0	$230.36	950	$66.50	$296.86
Wood	3,000	20	11.0	$201.65	950	$104.50	$306.15
Electric Heat Pump CoP 3.0	3,000	15	6.0	$251.30	950	$57.00	$308.30
Natural gas flued	2,000	15	18.0	$167.53	950	$171.00	$338.53
Wood pellets	2,700	15	12.0	$226.17	950	$114.00	$340.17
LPG Flued	2,000	15	22.0	$167.53	950	$209.00	$376.53

Source: NZIER

The table shows that although cabinet heaters have the highest annual running cost, reflecting the high cost of fuel, when combined with the annualised cost of purchase they have the third lowest total cost. Adding $22.50 to represent the average annual cost of biennial maintenance inspections by a qualified service agent would lift the total cost of unflued LPG cabinet heating above that of coal, wood burners and heat pumps. However, reinserting the 30% energy loss adjustment made by EECA, unflued LPG cabinet heating would rise to $406 total cost, making it the most expensive option.[7]

[6] The assumed effective life of an unflued LPG heater is the same as that in the Wakelin report; the shorter life for electric resistance heaters reflects the large proportion of inexpensive heaters which fail more frequently and may be cheaper to replace than repair. This drags the representative life span down, but some electric heaters may last considerably longer. The price of electricity of 24 c/kWh is comparable to the 23.69 c/kWh residential price in MED's Energy Data File (2009)

[7] The LPG flued option is less expensive than the unflued cabinet heater, despite its higher purchase cost, because flued systems use LPG in large bottles which is cheaper (ca. $2.50/kg) than LPG in 9 kg bottles (ca. $3.60/kg). The flued LPG prices used here and in Table 6 allow for 11% energy loss from heat discharged with combustion gases up the flue.

The comparative prices used by EECA have an LPG price towards the lower end of the observed range of LPG product prices ($3.60/kg). At the upper range ($3.89/kg), unflued LPG would have the 4th highest total annual cost; at the mid range ($3.72/kg) it would have the 5th lowest (6th highest) total cost of the ten options compared.

This relative ranking of cabinet heaters becomes less favourable with increases in the level of heating load, and also with increases in discount rate applied . An annual load of 950 kWh is equivalent to about 24% of the average annual household space heating load of 3,800 kWh per year according to the BRANZ HEEP results. As that load increases, the cost of heating with a cabinet heater also increases, relative to the alternative forms of heating, as is to be expected for an option with high operating costs. For a heating load of 33% of the average annual household space heating, cabinet heaters would be the 8th most costly of the 10 options in total cost terms based on EECA's comparative costs, even without adjusting for loss through adequate ventilation. The total cost would be around $379, only less than flued natural gas and LPG heating for that heat load.[8]

If householders are concerned with the total cost of heating, a cabinet heater need not appear an unduly expensive option if their space heating requirements are not great and the heater is operated without any ventilation. Operating it in this way, however, maximises the deleterious effects on indoor air quality with possible adverse effects on the health of the occupants – although this would depend on how much it is used and the extent of exposure of the occupants to raised indoor air pollution. If householders use an unflued LPG cabinet heater with adequate ventilation, incurring energy loss that may on some estimates be as high as 30% (but may be less), the private cost of operation will be higher but the hidden costs on indoor air quality will be lower.

These figures are not definitive of costs in actual use, but they illustrate unflued LPG heaters may appear to be an economical choice if they are not used heavily, for instance as a supplementary heater for use over short periods or in areas that are otherwise difficult to heat. That is dependent on not incurring significant energy losses through ventilation. The more heavily they are used the more costly they are as a heat source, and the greater the likely adverse effects of emissions on indoor air quality.

The table nevertheless illustrates the step change in purchase cost between the cheap heating options of portable electric plug-in and cabinet heaters, and the more expensive fixed installations like heat pumps, wood burners and flued heating systems. There are qualitative differences in the amount and distribution of heat around a house provided by each option which make the fixed installations more effective in heating the whole house, but that does not overcome the substantial financial hurdle involved in replacing a cabinet heater with some other heating. In practice, therefore, if portable cabinet heaters were to become unavailable, the next

[8] Changing the expected life of electric plug-in heaters from 7.5 years to 10 years or 5 years has only minor effect on the annualised cost of these heaters, insufficient to change the relative ranking of these heaters and cabinet heaters.

most likely option to take their place in most instances would be portable plug-in electric heaters.

3.4 Trends in consumption and pricing of LPG

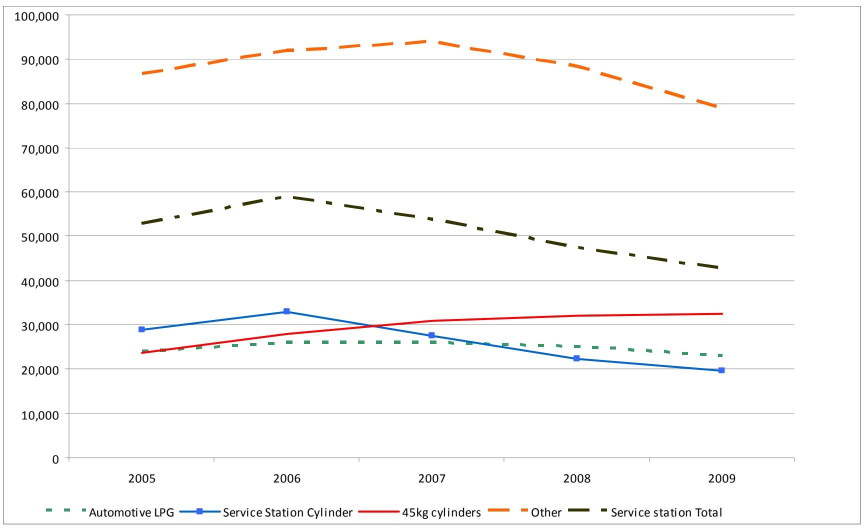
LPG's share of residential energy consumption in New Zealand remained static at about 4% over the 2005-2008 period, when electricity's share increased from 71% to 74% (MED EDF 2009). There is no direct dataset of LPG use in cabinet heaters, and total LPG consumption for this purpose is open to question because of the inter-changeability of the 9 kg bottles with other LPG appliances, such as barbecues. However, some inferences about the trend in use of these heaters can be drawn from recent annual LPG sales figures.

Figure 1 shows sales figures for LPG through different outlets in New Zealand. The largest volume category, "other", covers industrial sales and assorted retail outlets, but service stations account for a sizable proportion, split roughly equally between automotive fuels and filling of 9 kg bottles of the sort found in cabinet heaters. Although LPG bottles can also be filled at a few retail outlets, and swap-a-bottle schemes have appeared recently, most of the LPG bottles used in cabinet heaters are filled through service stations.

The figure shows that LPG sold through service station bottle filling has been in decline since 2006. Over the years 2005 to 2009, that decline was equivalent to an average annual rate of -7.3%. Automotive and other sales have also declined although at lower rates over the period: the automotive sales decline is equivalent to an average annual rate of -0.8%, and that of other sales to -1.9%. The only category of LPG that has increased over the period is sales in 45 kg cylinders, which grew at an average annual rate of 6.5%. Some of these 45 kg cylinders will be used to serve piped LPG systems in homes, but they also have institutional and industrial uses.

Figure 1 LPG sales in New Zealand

Tonnes per year

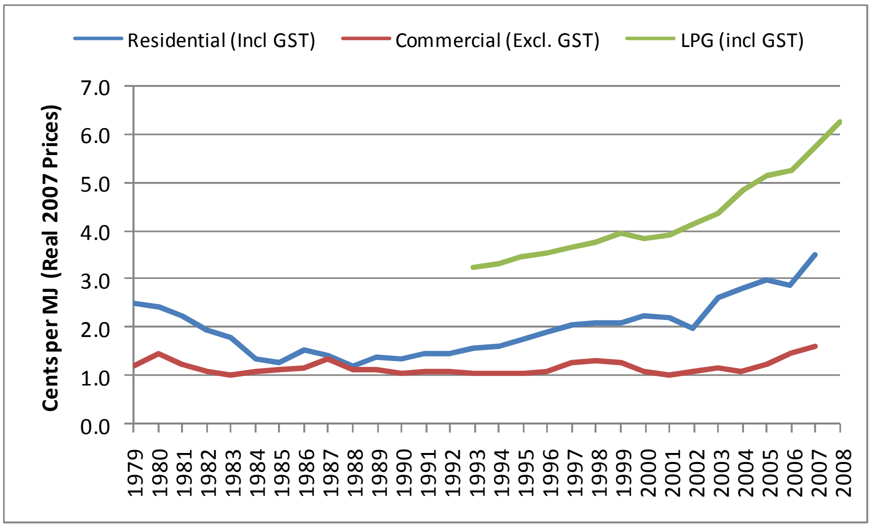


Source: LPGA

Service station bottle filling includes gas sold for purposes other than use in cabinet heaters. However, given the overall declining trend, unless the use of other LPG appliances such as barbecues and patio heaters has declined even more sharply, it is unlikely that LPG used in cabinet heaters will have increased. On the basis of these figures, service station bottle fillings accounted for 18% of total LPG sales in New Zealand in 2005, but this share had dropped to 13% by 2008.[9] The share attributable to cabinet heaters will be somewhat lower than this. Separating bottle filling sales in the winter months from those in the rest of the year would give a better indication of the use of LPG in cabinet heaters, but it has not been possible to obtain data in this format because of commercial sensitivities of the suppliers.

This is a similar trend direction to that reported by Wilton and Baynes (2009), who compared surveys of households using gas heating appliances in 2005 and 2008. Their figures suggest that between those years, the number of households using bottled gas in unflued heating declined by 56%, equivalent to -18.8% per year on average. Unflued bottled gas was used in the main living area of about 20% of all New Zealand households in 2005, but only 8% in 2008. They attribute this decline to the higher cost of LPG which climbed steadily between those dates (Figure 2). A 9 kg bottle refill is now typically in the region of $32 - $35, which equates to around 28-31 c/kWh but was around $25 five years ago.

Figure 2 Natural gas and LPG prices



Note: these LPG prices cover all retail sales and understate the cost for 9 kg bottles, which are now typically around $3.50/kg gas, compared to around $2.50 for LPG in 45 kg bottles.

Source: Wilton & Baynes (2009), using data from MED Energy Data Files and LPGA

[9] Cabinet heater LPG use = Service Station non-automotive sales + x% other 9kg sales – Y tonnes used in other LPG appliances (e.g. barbecues, patio heaters, camping and boating appliances).

We do not have sufficient data to estimate the price elasticity of demand for LPG heating, controlling for other influential variables, but rough indications of price responsiveness can be illustrated from the information above. The price of 9kg LPG bottle refills between 2005 and 2008 increased by 21% whereas sales declined by 23%, implying a crude price elasticity of -1.08. Over the same period the number of houses reporting having unflued bottled gas heaters in their main living area declined by 56%, implying a crude price elasticity of -2.67.

Increasing awareness of the health and safety aspects of cabinet heaters and the rapid uptake of heat pumps and other heating options in recent years may have prompted some substitution out of LPG heaters, or less reliance on them as a primary heating source. Although electricity has also experienced recent price increases, the price increase for 9kg LPG bottles over the 2005-2008 period was equivalent to an average annual rate of increase of 4.9%, which can be compared with corresponding rates of 2.8% per year for residential electricity and 7.2% for residential natural gas (all prices GST inclusive, constant dollar terms).[10]

3.4.1 The effect of insulation and clean heat subsidies

In recent years a number of national and local government schemes have been in place to encourage improvement in insulation and energy efficiency standards in residential properties. The latest of these is the Warm Up New Zealand scheme, introduced in May 2009, which provides a subsidy up to $1300 for professional installation of ceiling and under-floor insulation, and for those houses with adequate insulation a subsidy of up to $500 for installing clean heating devices. These schemes have been oriented towards replacement of open fires and other solid fuel burners, but they could also potentially encourage replacement of cabinet heaters.

Table 6 shows the uptake of heater subsidies under the Warm Up New Zealand scheme in the 10 months to the beginning of March 2010. This shows that of the 7,735 grants approved, just 57 (0.7%) were for replacement of unflued LPG heaters used as the principal heating source. Of that total, 4,675 grants went to households with a Community Service Cardholder (60%), of which 31 (0.7%) replaced unflued LPG heaters and 13 were to rental properties. A total of 20 unflued LPG heaters were replaced in 1,308 rental properties (1.5% of rental properties).

[10] Electricity and natural gas prices are from MED Energy Data File July 2009; LPG prices from Wilton & Baynes 2009.

Table 6 Uptake of Warm Up New Zealand scheme

	Total Properties	Community Service Cardholders	Rental Properties
Total uptake to March 2009	7,735	4,675	1,308
Of which LPG heater replaced	57	31	20
Of which CSC in rental properties		13	
Shares of all uptake			
Total uptake to March 2009	100%	60%	17%
Of which LPG heater replaced	0.7%	0.4%	0.3%
Of which CSC in rental properties		0.2%	
Shares of category uptake			
Total uptake to March 2009	100.0%	100.0%	100.0%
Of which LPG heater replaced	0.7%	0.7%	1.5%
Of which CSC in rental properties		0.3%	

Source: NZIER, from data provided by EECA

As the Warm Up New Zealand subsidies are only available for replacing the principal heating device, the uptake results to date suggest very few of the households receiving the subsidy use cabinet heaters as their principal heat source. The proportion replacing unflued LPG heaters is the same for Community Service Cardholders as it is for all properties. The proportion replacing unflued LPG heaters in rental properties is more than double that across the household population at large. The proportion of heater upgrades applying to rental properties, at 17%, is just under half the proportion of national households that occupy rental property (35%). This lends some support to the view raised in consultation that landlords of rental property are less likely than owner occupiers to invest in insulation and heating.

3.4.2 Cabinet heaters and national energy consumption

Although precise figures for LPG use in cabinet heaters are not available, the likely level of consumption can be estimated through other means. The HEEP results suggest the "average household" obtains each year 240 kWh of space heating from unflued LPG heaters (equivalent to 18.9 kg LPG per year per average household).[11] Applying this figure to the estimated 1.5 million households in 2005 implies a total of 28.4 kilo-tonnes of LPG used in cabinet heaters that year. That is equivalent to 98% of the 9kg refill sales by service stations that year, which is plausible allowing for further small bottle gas sales through other retail outlets to offset service stations' small bottle gas sales for uses other than cabinet heaters.

By 2008, a 21% increase in operating costs and a 23% reduction in LPG bottle sales would be partially offset by the growth in households. Other things held constant, the

[11] The 240 kWh national average per household equates to an average of around 950 kWh of heat output per house with LPG cabinet heater. This is 24% of the average household space heating energy and 8% of the average household total energy consumption. For estimation purposes this national average per household is assumed to have declined by 23% to 185 kWh, amounting to 17.8% reduction in LPG use after allowing for growth in the number of households.

net effect would be an 18% reduction in LPG used for cabinet heaters in that year, as shown in Table 7. The 2008 tonnage is 105% of the non-automotive sales of LPG through service stations, which again is plausible if sales other than service stations (e.g. retailers' swap-a-bottle schemes) have accounted for increasing share of small bottle sales. It could overstate the LPG used in heating in 2008, as price rises and other factors may have further reduced the average amount of heating from this source.

Table 7 Consumption of LPG in unflued heaters

Consumer prices, GST inclusive

		2005	**2008**	*Change*
Total Households		1,502,375	1,603,500	*6.7%*
Average heating from LPG	kWh/yr	240	185	*-23.0%*
Average kg of LPG for heating	kg/yr	18.9	14.6	*-23.0%*
Aggregate LPG for heat	kt	28.4	23.4	*-17.8%*
LPG heating	GWh/yr	360.6	296.3	*-17.8%*
LPG heating	PJ	1.30	1.07	*-17.8%*
Cost per kWh		$ 0.23	$ 0.28	*23.5%*
Aggregate cost of LPG	$M	82.931	84.157	*1.5%*
LPG/NGL Consumer energy	kt	157.3	174.5	*10.9%*
Unflued heater share of LPG		18.1%	13.4%	*-25.9%*
CO2 equivalent	kt	85.3	70.1	*-17.8%*

Source: NZIER, using data from HEEP, EECA, MED EDF (2009)

Note: The aggregate cost of LPG in cabinet heating for 2008 is based on the EECA price of 28.4 c/kWh. At the mid-range price of $29.3 c/kWh, the aggregate cost would be $86,824 million for the year, and at the top range price of 30.7 c/kWh it would be $90.972 million, but all other figures in the table remain unchanged.

On balance therefore it seems likely that cabinet heaters have accounted for a declining share of LPG consumption in New Zealand in recent years, from around 18% in 2005 to 13% in 2008. The figures for LPG heating output in Table 7 are lower that those in Wilton and Baynes (2009) who suggest around 2.7 PJ of 2006 LPG consumption (32% of total) was used in residential space heating in 2006 (p 25). That may be due to estimation differences, but it is also partly explained by their category of LPG heating including more than just cabinet heaters, and by 2006 being a peak year for sales through service stations (Figure 1).

LPG is a by-product of natural gas production, traditionally sourced from the Maui and Kapuni fields. Up to 2000 New Zealand produced more LPG than it consumed and exported the surplus. Since 2001 however the Maui and Kapuni fields have fallen into decline and domestic LPG production has fallen. In 2003 New Zealand started importing LPG and imports have accounted for an increasing share of the New Zealand market, amounting to 58% in calendar year 2008 (MED *Energy Data File* 2009). The recently commissioned Kupe field and proposed McKee production station could supply New Zealand with considerably more LPG than in recent years, to the extent that it could once again be exporting LPG in the near future.

The price charged for LPG reflects these market changes. Having previously relied on relatively abundant and cheap LPG from Maui and Kapuni, in 2006 New Zealand became a net importer of LPG and domestic prices became reflective of international pricing benchmarks, particularly the Saudi contract price and importation costs. The costs of importing LPG have contributed to recent rise in LPG prices.

LPG in New Zealand is distributed by 6 wholesaler-retailers – On Gas, Rockgas, Genesis Energy, Nova LPG, BOC NZ (Elgas) and Yunca – and a further 12 retailers, of which the petrol retailers Shell, BP and Caltex are the most prominent in serving the market for refilling 9 kg bottles.

LPG cabinet heaters have been available in recent years through various retailers, including Bunnings and Mitre 10. Some retailers such as Placemakers and the Warehouse are now considering a policy change not to stock them, as they are considered inconsistent with their corporate marketing position.

Recent LPG price rises may be reversed if production from Kupe and McKee returns New Zealand to a position of net exporter of LPG, as the costs of transport will tend to improve returns from sales to the New Zealand market relative to exports. If that happens there may be some recovery in the recent decline in use of cabinet heaters. If cabinet heaters account for 12-17% of local LPG consumption, further curtailment of that demand may have little effect on prices as these are set by the supply at the margin that would still consist of imported product. It is difficult to assess what effect further curtailment would have on the the distribution of LPG around the country, as although much of this depends on variable tanker wagon movements there could also be impacts on storage infrastructure.

A move to phase out the use of cabinet heaters, whether driven by market forces or regulatory measures, is likely to increase electricity consumption and have implications for the electricity market and security of supply, particularly in relation to peak winter demand. The estimated 2005 output of 360 GWh from cabinet heaters would require 388 GWh of replacement electricity generation, allowing for average 7.5% losses on transmission and distribution (MED EDF 2009), which in turn is equivalent to 44 MW of generation capacity running continuously through the year; the estimated 2008 output of 296 GWh would require 319 GWh of replacement electricity generation after allowing for distribution losses, equivalent to 36 MW of generation capacity. As in practice generation plant are not run continuously through the year because of maintenance and other down-time, and replacing the output of these heaters would add most to the morning and afternoon peaks in winter, the generation capacity brought into production to meet those demands would be rather more than the figures outlined above. This could necessitate the bringing forward of new investments in new generation capacity, transmission and distribution lines.

To put this in perspective, in 2008 New Zealand had 9,380 MW of installed generation capacity that supplied a total of 42,246 GWh. Residential sector electricity consumption was 12,417 GWh (MED *EDF* 2009). The estimated 2005 cabinet heater output of 360 GWh is equivalent to 2.9% of residential electricity consumption; the estimated 2008 cabinet heater output of 296 GWh would be 2.4% of residential electricity consumption. Relative to total electricity generation the contribution of LPG cabinet heaters is about 0.8%. In its 2008 *Statement of Opportunities*, the Electricity

Commission forecast electricity consumption growth of 1.4% per year over 2007-2025 period, which would mean average annual increase in consumption of around 600 GWh. Replacing LPG cabinet heater output with electricity would require over 50% increase on the projected growth in one year, which is likely to necessitate rescheduling of new investments in electricity generation, transmission and distribution facilities. A reduction in cabinet heater use over a longer period would have smaller proportional impact and less effect on investment scheduling.

Increased energy demand in the South Island could limit the availability of hydro-power for meeting North Island demands, particularly after 2012 when current capacity constraints on the inter-island link are expected to be relieved. Taking up the cabinet heater load could result in increased North Island thermal generation in the short term and accelerated generation developments in the longer term. There may also be issues with the capacity of local lines networks: some have assessed this eventuality already but each local line company would need to assess its own situation in light of the local situation and expected rate of transfer of heating load from LPG heaters. [12]

It is not possible to accurately assess implications for the electricity market without greater detail of the nature of the changes and where extra loads are required across the electricity system. However, the more slowly heating load is switched from LPG to electricity the more readily the electricity system can accommodate it and plan for adjustments in operational and investment activities.

3.5 Social cost of injury and property damage

Many accidents cause fire. Most other accidents cause injury, health effects and property damage mainly due to explosion, gas leak and CO poisoning.

The social costs include cost of fatalities and injuries as well as property damage. The social cost of injury is the total loss to society due to loss of life and life quality and treatment of injuries and any other associated costs.

3.5.1 Injury data

Energy Safety records show that during the seventeen year period 1993-2009, there were 249 accidents associated with cabinet heaters investigated by Energy Safety, of which 104 were notifiable and 145 were non-notifiable.[13] Out of the 104 notifiable accidents, 8 fatal accidents caused 9 fatalities and 35 injury accidents caused 43

[12] A report jointly prepared by Orion, Meridian and Environment Canterbury (Orion et al 2009) into that region's Clean Heat programme concluded that household electricity demand was not increased, and sometimes reduced, by replacement of fires with cleaner heating appliances, because inefficient fires were often run in conjunction with electric resistance heaters which were used less after the conversion. That report does not consider whether shifting of peak load demands necessitated changes to operation or investment on the local network.

[13] As defined in the Gas Act 1992, notifiable gas accidents are accidents that result in serious harm to persons or significant property damage; non-notifiable gas accidents are accidents that cause injury and/or property damage below the threshold of notifiable accidents.

non-fatal injuries. Most of these fatalities were due to fire. Only one accident causing one fatality was due to CO poisoning. All non-fatal injuries recorded by Energy Safety are due to accidental fire.

The 43 non-fatal injuries include 6 serious injuries, 6 moderate injuries and 31 minor injuries, as categorised by Energy Safety. It is not clear to what extent these cover all injuries. These are notifiable and non-notifiable injuries reported to Energy Safety. Considering these as the total number of injuries that have occurred during this period may give conservative estimates.

For social cost estimation, the important data are 9 fatalities, 12 moderate-serious injuries and 31 minor injuries.

In general, non-notifiable accidents cause less severe damage than notifiable accidents. The 145 Non-notifiable accidents caused 16 minor injuries – but without any long term consequence – minor burns, for example. Still there may be some loss of life quality due to burns mark depending on where they occur. We understand from Energy Safety that these are very minor and unlikely to have any loss of life quality. Taking that into account we treat them as injuries causing only short term inconvenience.

There might have been other accidents, which have not been reported because they are not notifiable or because the consequence of damage is not large enough for someone to bring it to the attention of Energy Safety.

Energy safety does not include incidents which are not related to fuel use, such as accidents and injuries due to collision with the heater when it is not on, or if the heater falls down due to some other factor e.g., earthquake or children playing around it. Even though these are not related to fuel use, they are still accidents related to having portable cabinet heaters. These accidents would not have occurred if the heaters were not being used at some time in the house. However, in the absence of any information, we have not been able to estimate the number of such accidents.

3.5.2 Social cost of injuries

The social cost of injuries is based on the concept of value of statistical life as used in New Zealand for transport appraisals. Based on survey results, the Ministry of Transport (MOT) estimates the loss of life quality due to a serious injury as 10% of the value of statistical life (VOSL)[14] and due to a minor injury as 0.4% of VOSL.

What Energy Safety defines as moderate injuries falls under the serious injury category in the transport injury definition. Minor injuries related to cabinet heater accidents can be of lesser long term consequence than minor injuries in traffic accidents.

[14] See appendix B for a discussion.

For minor injuries from notifiable accidents, we use the MOT estimates. However, we also vary the loss of life quality component to 50% of MOT estimate. In some non-notifiable accident injuries, there are inconvenience, in some cases there is no medical treatment and there are other variations. We evaluate these injuries in the same way. However, we have also made an alternative estimate assuming the average cost for such injuries would be about 50% of medical costs estimated by MOT for minor injuries. This would be the case if these minor injuries all have only small short term effects and there is no loss of life quality.

Table 8 Social costs excluding property damage during 1993-2009

Injury type	Social cost per injury ($)	Number of injuries	Total social cost ($ million)
Fatal	3,511,100	9	31.600
Serious	364,200	12	4.370
Minor (notifiable)	14,800 (7,800)	31	0.459 (0.242)
Minor (non-notifiable)	14,800 (400)	16	0.237 (0.006)
Total			36.666 (36.219)

Notes: (1) Social cost per injury is from Ministry of Transport (2009)

(2) Figures in parentheses indicate alternative estimates

Source: NZIER

As shown in Table 8, most of the social costs are due to fatal and serious injuries. The contribution of minor injuries is small. So whether the loss of life quality due to minor injuries is included or not would not make much difference in the estimates, unless the number of such injuries is much larger, i.e., there is a large gap in the data.

3.5.3 Cost of damage to structure and house contents

The New Zealand Fire Service estimates costs of damage to building structures due to fire. When an accident causes fire that affects the house structure, it is expected that there would be damage to house contents as well.

The average cost of content damage is not readily available. Tower Insurance recommends that the average value of house contents should be about 40% of the house value. This provides guidance of loss due to damage to house contents to be about 40% of the value of damage to the house structure. In the absence of a better estimate we assume that the total loss is equal to 1.4 times the cost of repairing the structures.

We obtained estimates of cost of damage for house fires caused by portable LPG heaters from New Zealand Fire Service (NZFS). Portable LPG heaters include both cabinet heaters and patio heaters. It is not clear, to what extent the house damage caused by fire due to patio heaters would be different from damage due to cabinet heaters as they are used in different types of place. We assume that the average cost of fire damage due to cabinet heaters would not be much different from the NZFS overall average cost for all portable LPG heaters.

We understand from NZFS that their estimates prior to 2002 were not reliable as the records were being kept manually. The data for 2009 also appear to be incomplete due to industrial action by fire fighters. So our estimate is based on the data obtained for the period 2002-2008 (Table 9). It is based on adjustments to these cost figures drawn from a recent report (Page 2009).

The number of fires causing damage to houses during a year varied between 16 and 45 over these seven years.

Table 9 Estimated cost of structure fires

Year	No of structure fires	Total estimated cost ($)	Average cost per house ($)
2002	46	1,453,986	31,608
2003	30	722,673	24,089
2004	23	474,709	20,640
2005	18	633,050	35,169
2006	20	482,352	24,118
2007	27	1,013,834	37,549
2008	16	580,904	36,307

Source: NZ Fire Service, NZIER

This provides an overall average cost of $29,786.16[15]. However, all these costs are estimated at current prices of each year. Converting all costs to 2009 prices using CPI, the average cost of damage to structures is estimated as $33,600. If cost of damage of house contents is 40% of this, then the total cost per fire would rise to $47,100 per house. If the cost of contents damage is 30% then the total cost is estimated as $43,700. The recommended value of contents insurance is likely to differ from the actual costs. The actual cost is more likely to be on the lower side. We have used both in our estimates .

It is expected that non-notifiable accidents would have lesser damage than notifiable accidents as by definition notifiable accidents are of more serious nature. It is also expected that NZFS figures include mostly notifiable accidents. On the other hand, NZFS figures include costs of accidents involving patio heaters, which are expected to have relatively low damage. In the absence of more precise information, we have used the average property damage costs for all accidents causing structural damage by fire.

[15] For all house fires, NZFS estimates the average cost of damage per fire as $42,000.

a) Number of accidents causing fire

According to Energy Safety figures, structural damage due to fire occurred in 92 accidents (79 notifiable and 13 non-notifiable), 62 (15 notifiable and 47 non-notifiable) occurred in the vicinity of heater and 85 (10 notifiable and 75 non-notifiable) accidents damaged only the heater. For 10 non-notifiable accidents, the damage area is unknown. If we distribute them pro rata using only non-notifiable accidents, then these would be 1 structural damage accident and 9 non-structural damage (3 vicinity of heater and 6 only heater). This suggests structural damage occurred in 93 accidents, vicinity of heaters accounted for 63 accidents and 91 accidents had only heater damage.

There is no information on cost of damage in the vicinity of heater and heater only accidents. We assume some very rough figures of $10,000 and $200 per accident respectively for these two types of damage.

This gives a total cost of $4.735 million, using $43,700 per structural damage accident. It is $5.051 million if we use $47,100 per structural damage accident. Most of the costs occur from structural damage (i.e., excluding costs of contents lost): $4.062 and $4.379 respectively.

3.5.4 Total social cost

There are considerable uncertainties on severity of injuries, in particular minor injuries, as well as on costs of damage to properties (structural and house contents). Besides, there are uncertainties on actual number of accidents and damages that occurred during the 17 years for which we have collected the data.

The social cost of injuries, based on the available data as described above, is estimated as between $36.2 and $36.7 million for the two options of damage to contents. The estimated cost of property damage is between $4.7 million and $5.1 million. Thus the estimated range for the total social cost over the seventeen year period is between $41.0 million and $41.7 million.

This gives an average social cost between $2.4 million and $2.5 million per year.

Two unit costs were just guessed estimates, i.e., the average cost per accident causing damage in the vicinity of the heater and damage of only the heater. If the average cost of damage is only $2,000 in the first case, instead of $10,000 noted earlier, and the cost per heater damage accident is only $100 instead of $200, the average social cost is still around $2.4 million per year, with a range between $2.38 million and 2.42 million. So the total social cost per year is slightly lower but given the uncertainties in the estimates, a round figure of $2.4 million is reasonable.

3.5.5 Data gap and consequences

a) Total number of accidents

The figures received from New Zealand Fire Service are considerably higher than those received from Energy Safety. One big difference between the two sets of numbers is that NZFS figures include accidents due to portable LPG patio heaters along with portable cabinet heaters. For some years the difference is large (Table 10). NZFS data also includes all accidents where a cabinet heater or patio heater is involved in the accident, though not necessarily the cause of the accident. If fire breaks out and the LPG heater gets affected and bursts into flame, that would not be included in the Energy Safety data but included in the NZFS data. There may also be a small number of minor non-notifiable accidents not found in ES data because they are not required to be reported, but these are not a major contributor to the social cost of cabinet heater accidents (see Table 8).

The Energy Safety data include both fire and non-fire accidents, while NZFS data include only fire damages.

Table 10 Number of accidents

Year	Energy Safety data			NZFS data	Difference
	Notifiable	Non-notifiable	Total		
2002	6	14	20	46	26
2003	13	10	23	30	7
2004	5	9	14	23	9
2005	10	8	18	18	0
2006	5	2	7	20	13
2007	12	5	17	27	10
2008	6	2	8	16	8
Total	57	50	107	180	73

Source: Energy Safety, NZFS, NZIER

b) Injury and injury severity

It has been assumed that all injuries are recorded in the Energy Safety data set. If not, we have underestimated the total social cost. However, if all the deaths and serious injuries are included, then any gap in recording of minor injuries would make only small differences.

We have used the same loss of life quality and medical costs for minor injuries due to non-notifiable accidents and also very low value for these. This does not cause much difference.

c) Length of time

The accident data provided by Energy Safety covers 17 years from 1993 to 2009. A large proportion of accidents, more specifically fatal accidents (5 out of 8) have occurred during the last three years. Given the low risk of accidents, analysis of data over a short period is likely to produce biased results. In this particular case, there is a risk of overestimation if we consider only the last five years or so. On the other hand, more recent data may be more accurate. We understand from NZFS that they have more confidence on data for the period 2002-2008, which we have considered for estimating the average property damage cost. If we used the same period for fatal and injury accidents as well then the social cost per year would be higher. But that would not necessarily provide better estimates.

3.6 Social cost of health effects

There are only limited number of studies on health effects of using cabinet heaters. Some studies look at the effects of unflued gas heaters in general. Because unflued gas heaters produce large quantities of water vapour, it may lead to prevalence of mould, dust mites and bacteria. Another effect is CO poisoning. As we understand, unlike nitrogen dioxide (NO_2), CO does not occur in dangerous concentrations unless there is some malfunction of the heater. Although severe CO poisoning can be fatal, it is not clear if mild CO poisoning has some long term effects. We understand from Energy Safety that one accident caused one death due to CO poisoning and two accidents caused six minor injuries. We have included these in our estimates of social costs of injuries. Here we discuss mainly the effects of nitrogen dioxide and those of dampness and related consequences.

3.6.1 Effects of nitrogen dioxide

Air pollutant NO_2 is formed by combustion of fossil fuels and studies indicate that it affects asthma attacks (Pilotto et al 2003). Because NO_2 may cause inflammation of airways, people already suffering from asthma are likely to be adversely affected by NO_2 produced by unflued gas heaters. However, such findings are observed mainly for children and no definite link has been identified for adults (enHealth 2007). The effects on asthma patients are also emphasised in some New Zealand studies (Concept Consulting Group Limited 2009, Howden-Chapman et al 2008).

A study by Pilotto et al (2003) determined the relative risks of asthma attacks and chest tightness in children in Australian schools when unflued gas heaters were replaced by flued gas or electric heaters. All children selected for the study had asthma problems. While there was general improvement, statistically significant improvements were noticed for “difficulty in breathing during the night” (RR = 0.32), “difficulty in breathing during the day” (RR = 0.41), “chest tightness during the day” (RR = 0.45), “asthma attacks during the day” (RR = 0.39). “Asthma attacks during the night” (RR = 0.38) were also lower but not statistically significant at 5% level.

This suggests that if a flued gas heater is used instead of an unflued gas heater, the number of asthma attacks would be reduced possibly to about 39% of the level with unflued gas heaters. This amounts to a reduction of about 60% of asthma attacks.

A New Zealand study (Howden-Chapman et al 2008) examined the effect of upgrading home heating on 349 children aged 6-12 years with doctor diagnosed asthma. The study had 175 children in the intervention group, who had alternative heating source (heat pumps, wood pallet burner or flued gas) and 174 in the control group using unflued gas or plug-in electric heaters. The study found over the period of 4 months (June – September, 2005) that the intervention group children had

- 1.8 fewer days off school compared to 9.47 days for the control group – a reduction of 19%
- 0.40 fewer visits to a doctor for asthma compared to 1.33 visits for the control group – a reduction of 30%
- 0.25 fewer visits to a pharmacist for asthma compared to 0.37 visits for the control group – a reduction of 68%

They estimated a few other measures which provide some more complicated information. So we have discussed these three factors here.

Because the control group had either unflued gas heater or plug-in electric heater, the difference does not necessarily indicate the effect of cabinet heaters alone on asthma patients. There are two factors to be considered.

- Plug-in electric heaters do not cause such adverse effects on asthma patients. Therefore, if only LPG heaters were replaced by non-polluting heaters (heat pump or flued gas heaters), then the effects should have been higher.
- On the other hand, the study was to improve house heating and the effect on health might have been due to better warmth in the house.

One of the effects measured was reduction in number of days off school. This could also be due to better health as such – not just asthma related but also susceptibility to colds and 'flu etc. It is not possible from the study to determine how the two opposing effects nullified each other and what would be the net effect.

The data for cabinet heaters alone from this study were obtained for analysis in this review. That also shows that the number of visits to a doctor for asthma would be reduced by about 30% if cabinet heaters were replaced by non-polluting heaters. We would expect much higher reduction as plug-in electric heaters should not increase the doctor visits. It seems the smaller sample size of households with only cabinet heaters in that study raises doubt on the robustness of this estimate[16].

3.6.2 General effects

All these study results are related to asthmatic children. A New Zealand survey indicates that about 12% of cabinet heater users experienced some health problem during the previous 12 months (Fryer et al 2006).

[16] The estimate is statistically significant at only 7% level, while the estimate for households with either cabinet heater or plug-in electric heater or both types was statistically significant at 1.2%.

a) Estimate of effects on asthma

The Asthma Foundation website indicates that about 25% of children in New Zealand suffer from asthma. The number of children up to 12 years of age is estimated by Statistics New Zealand as 768,850[17]. This suggests that number of children suffering from Asthma is about 192,213 (25%). According to Howden-Chapman et al (2009), about 28% of households use bottled gas as heating fuel and the 2006 census figures suggest a lower rate of about 26%. Many of these heaters are used in garages or workshops. According to Wilton and Baynes (2009), only about 127,120 household use bottled unflued gas heaters in their living areas (2008 estimate). This is about 8% of all households.

If this is also true for households with children suffering from asthma, then the number of asthmatic children exposed to unflued gas heater is about 15,377.[18] As discussed in section 3.1, a large proportion of bottled LPG gas heaters are cabinet heaters. As shown in Table 7, there was a reduction in use of LPG heaters in 2008 from the level in 2005 by about 18%. This would indicate the Census estimate of 26% would be reduced to around 21% and that percentage may be reducing further in face of continuing growth in the number of households. Given this, it would be reasonable to assume that cabinet heaters are used in about 20% of households.

The distribution of cabinet heater users found in a survey by Fryer et al (2006) shows that 19% have family income below $30,000, 45% in the range of $30,000-$70,000 and 36% above $70,000. The income distribution of population in these three categories is 40%, 38% and 23% respectively. It is not clear if asthmatic children exposed to cabinet heaters also have similar distribution of family income. If the distribution of cabinet heaters is not affected by income distribution of families with asthmatic children, then the estimated number of asthmatic children exposed to these heaters would be about 20% of 192,213 or 38,443.

In the absence of more precise figures we use these estimates as possible levels of improvement if Cabinet heaters are replaced by flued gas or electric heaters or heat pumps. We have presented three sets of estimates using 19%, 30% and 60% reductions from Howden-Chapman et al (2008) and 60% reduction from Pilotto et al (2003).

3.6.3 Asthma quality of life

Estimates of how asthma affects quality of life of asthmatic patients vary between 0.77 to 0.97 (Abelson 2003), where 1.0 is normal health without asthma. Abelson estimates the quality of life of asthma sufferers based on Tolley et al (1994) as 0.86 and Mathers et al (1999) as 0.77-0.97. In the latter estimates, 0.97 refers to mild asthma and 0.77 refers to acute asthma. The average would be about 0.87. Selecting and interviewing asthmatic children aged 4-17 years and their care givers,

[17] http://www.stats.govt.nz/methods_and_services/access-data/tables/national-pop-estimates.aspx

[18] The true figure could be higher than this if asthmatic children are clustered in homes using LPG heaters, or lower if clustered in homes without such heaters, but this cannot be distinguished from available data.

Levy et al (2004) estimate the quality of life of asthmatic children as 0.81[19]. These studies indicate that on average between 13% and 19% of life quality is lost due to asthma attacks.

Our understanding is that an increase in NO_2 level does not increase the number of asthma sufferers but increases the level of their suffering during the period of exposure or for a while following the exposure. There can be a serious or minor consequence depending on the acuteness of asthma attacks the person is suffering from. For intense sufferers there is a possibility of severe consequence including death. However, for many it is likely to be higher level of discomfort at least for the winter period.

Only limited information is available on severity of asthma conditions and its distribution in New Zealand. According to the Asthma Foundation website[20], about 600,000 people in New Zealand suffer from asthma. The latest information on number of deaths due to asthma severity is available only for the period 1990-1998, when between 118 and 197 people died in each year. This suggests the risk of death due to asthma is between about 1 in 5,000 and 1 in 3,000.

A report (The Burden of Asthma in New Zealand) by Holt and Beasley (2001) for Asthma and Respiratory Foundation of New Zealand (Inc) indicates that the risk of death is lower for children than for adults. Also, over time there is a tendency for the death rate to reduce. Considering this, we have also included an option of risk as 1 in 10,000.

This report mentions that the death rate from asthma is 1.05 per month per 100,000 children in the age group of 5-14. The number of children in this age group in 2009 estimated by Statistics New Zealand is 585,700. This suggests that number of deaths from asthma for this age group alone would be about 74. This would indicate a death rate of 1 in about 2,000. The report also suggests that the average monthly death rate for people in the age group of 15-44 is 2.87. Based on the estimated population of 1,796,600 in this age group, the number of deaths would be about 619 per year. These figures are considerably higher than the figures noted in the Asthma Foundation website[21]. However, the report shows a declining trend in the death rate over recent years. Considering this we have used the figures presented in the Asthma Foundation website and assumed further reduction in risk.

The total number of hospital inpatients and day patients in 2001/02 was about 8,000 for asthma, with average stay at hospital for about 3.6 days.

These are yearly rates. Exposure to NO_2 from cabinet heaters occurs mainly during the winter period. It can be argued that the death rate should, therefore, be reduced to reflect the period of exposure. This would be the case if the worsening symptoms

[19] In all these cases, 1 means normal life and 0 means death.

[20] http://www.asthmanz.co.nz/in_new_zealand.php

[21] The report does not specifically mention if the rate provided is for 100,000 people in the age group or 100,000 asthma sufferers. If it is the later, then also the rate of death provided there is on the higher side.

of asthma disappeared immediately when the cabinet heater was not used. The literature does not clearly indicate the long term effects of NO_2 exposure. If the effect stops with removal of a cabinet heater, then the death rate considered for the study should be lower. On the other hand, if NO_2 exposure causes medium or long term worsening effects, then the death rate should be the same or even higher. This would be the case if for an asthmatic child exposed to a cabinet heater and hence higher level of NO_2, the condition of asthma after the winter season is worse than what it was before the winter.

The US National Institute of Health notes in their website[22] that “when the airways react, the muscles around them tighten, This causes the airways to narrow". If allergic reaction to NO_2 over the winter period causes any narrowing effects, then it is likely that the effect will be felt at least for a while after the exposure is stopped.

There is another factor that enHealth (2007) points out: “some of the components of pollutants of unflued gas heater emissions are associated with adverse effects on the respiratory system, particularly in people with asthma” (p 43). This suggests the likelihood of some long term effects.

enHealth (2009) also notes that “exposure to unflued gas heaters in infancy may increase the risk of asthma later in childhood” (p 43). Our analysis is confined to children with asthma and it is assumed here that unflued gas heaters do not cause asthma. If it does then there is higher social cost than what has been estimated.

Taking all these factors into consideration, our view is that it would not be unreasonable to use the yearly rate.

3.6.4 Social cost estimates

A loss of life is valued at $3.5 million at 2009 prices. The medical and other related costs including loss of output of carers is estimated at $825 million a year by the Asthma Foundation. This is equivalent to about $1,375 per asthma patient per year.

If the loss of life quality is 15% on average, then the social cost of loss of life quality of 600,000 asthma sufferers is over $300 billion[23].

For the estimated 38,443 asthmatic children, exposed to cabinet heaters, the social cost would be about $20 billion. This indicates the high social cost of loss of life quality due to asthma in New Zealand.

[22] http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html

[23]This is the lifetime cost of pain and suffering for asthma sufferers - not the cost per year – and cannot be meaningfully compared with annual GDP. Such a comparison is misleading because the social cost of loss of life and life quality is the welfare cost of pain and suffering – not the resource cost. In this estimate we have only considered the value of loss of life quality which for asthma sufferers is estimated as 15% of normal life. It does not include any resource cost.

a) Savings in social costs

If Cabinet heaters are replaced by some type of non-polluting heaters, e.g., electric heaters or flued gas heaters, there will be less asthma attacks. This reduction is estimated as between 19%-60% using Howden-Chapman et al (2008) findings and Pilotto et al (2003) findings.

The savings in number of deaths when cabinet heaters are replaced by non-polluting heaters are estimated as 38,443 *(19%-60%)*(1 in 10,000, 1 in 5,000, 1 in 3,000). This gives a range of number of deaths that can be avoided of between 1 and 8 per year.

The social costs are estimated as number of deaths times $3.5 million (value of statistical life). The total financial cost of other health effects is estimated as number of cases times $1,375.

This provides estimates of social cost varying between $13 million for 19% reduction and $59 million for 60% reduction (Table 11). At the risk of death of 1 in 10,000, this range would be $13-40 million per year.

Table 11 Estimated social cost savings for children up to 12 years

Risk of death	Rate of risk reduction in asthma suffering		
	Howden-Chapman et al (2008)		Pilotto et al (2003)
	Days off school 19%	Visits to doctor 30%	60%
	Number of deaths		
1 in 10,000	0.7	1.2	2.3
1 in 5,000	1.5	2.3	4.6
1 in 3,000	2	4	8
social cost of deaths avoided ($ Million)			
1 in 10,000	2.56	4.04	8.07
1 in 5,000	5.11	8.07	16.15
1 in 3,000	8.52	13.45	26.91
Other social costs			
Affected number of asthma sufferers	7,304	11,533	23,066
Savings in financial costs ($ Million)	10.04	15.86	31.72
Total savings in social costs ($ Million)			
1 in 10,000	12.60	19.89	39.79
1 in 5,000	15.16	23.93	47.86
1 in 3,000	18.56	29.31	58.62

Source: NZIER

It is not clear to what extent the days off school indicate the level of severity in asthma attacks. Perhaps the visits to a doctor is a better indication. In that case the total social cost savings per year of replacing cabinet heaters with non-polluting heaters should be between \$20 million and \$29 million. If we consider the Pilotto et al (2003) estimate, the savings in social cost would be between \$40 million and \$59 million per year. Using the Howden-Chapman et al estimates of reduction in doctor visits, we can say that the average saving in social cost would be about \$27 million per year. It is about \$22 million per year if we consider only the first two rates of death.

b) Based on NO_2 measure

Studies show increase in asthma symptoms with increase in NO_2 levels. However, we have not come across a definite relationship with NO_2 levels and increase in general asthma suffering.

An Australian study (Nitschke et al 2006) estimates the effects of increase in indoor NO_2 level. This study shows that for a 10 ppb[24] increase in NO_2 exposure “difficulty in breathing during the day” increases by 9%, “difficulty in breathing during the night” increases by 11% and “chest tightness during the night” increases by 12%, in asthmatic primary school children in Adelaide.

An American study (Hansel et al 2008) finds that an increase in concentration of NO_2 increased respiratory symptoms in Baltimore inner-city pre-school children with asthma. These children were predominantly African-American. The study also notes that many inner-city households used gas stoves, an important source of indoor concentration of NO_2 since many of these stoves are unvented.

This study indicates that for every 20 ppb increase in NO_2 exposure, “a child would experience 10% more days of cough symptoms or 15% more days with limited speech due to wheeze” (p 1431). “Importantly, NO_2 was consistently associated with coughing, nocturnal symptoms, and limited speech, even after adjusting for potential confounders and other pollutants” (p 1431).

These two studies have looked at different symptoms and come up with a range of changes in suffering from asthma. We make a rough estimate here looking at the difference in NO_2 level observed in the Howden-Chapman et al (2008) study data for cabinet heater users. It showed that the average level of NO_2 in the control group was about 53$\mu g/m^3$ on average and it was reduced by 40 $\mu g/m^3$ when heaters were replaced by non-polluting heaters. This is equivalent to a reduction of about 22 ppb.

If a reduction in 10 ppb NO_2 reduces the level of asthma suffering by 10%, then for every 22 ppb reduction, the suffering would be reduced by about 22%. This would give an estimate of reduction in social cost by about \$15-41 million per year (Table 12) for children up to 12 years of age.

[24] ppb: parts per billion

Table 12 Estimated social cost savings for children up to 12 years using NO_2 estimates

Risk of death	Rate of risk reduction in asthma suffering	
	42% reduction	22% reduction
	Number of deaths	
1 in 10,000	1.6	0.8
1 in 5,000	3.2	1.7
1 in 3,000	5.4	2.8
social cost of deaths avoided ($ Million)		
1 in 10,000	5.65	2.96
1 in 5,000	11.30	5.92
1 in 3,000	18.84	9.87
Other social costs		
Affected number of asthma sufferers	16,146	8,457
Savings in financial costs ($ Million)	22.20	11.63
Total savings in social costs ($ Million)		
1 in 10,000	27.85	14.59
1 in 5,000	33.50	17.55
1 in 3,000	41.04	21.50

Source: NZIER

Pilotto et al (2004) find a reduction in NO_2 level by about 31.5 ppb when unflued gas heaters are replaced by flued gas or electric heaters. This corresponds to a reduction of asthma attacks by about 60%. According to this estimate, 22 ppb would reduce asthma attacks by about 42%. The reduction between 22% and 42% provides a reasonable range of likely effects of NO_2 exposure from cabinet heaters. This covers also the range found in Howden-Chapman (2008) study. The higher estimate by Pilotto et al (2004) could be due to higher level of NO_2 level difference.

Since it is likely that the death rate from asthma would be on the lower side for children we discuss only the first two risk levels, i.e., 1 in 10,000 and 1 in 5,000.

In that case, at 42% reduction rate, the reduction in social cost would be between $28 million and $34 million for the two levels of risk of death (1in 10,,000 and 1 in 5,000). At the reduction rate of 22%, the range would be $15-18 million per year for children up to 12 years of age.

3.6.5 Including all children up to 17 years old

The number of children in the age group of 13 to 17 is 313,110. If the same proportions (as assumed above) of these children are exposed to cabinet heaters and asthma suffering, then the number of affected children would be 15,656.

Studies did not find any significant effect of exposure to unflued gas heaters on asthmatic adults, as discussed above. However a New Zealand study shows that adults expressed some experience of discomfort when exposed to cabinet heaters. It is also not clear from the studies discussed above what is the effect of NO_2 on asthmatic children above 12 years of age. We have estimated the effects assuming the following two scenarios:

- The average effect is similar to that for children up to 12 years of age
- The average effect is about half of that for children up to 12 years of age.

The estimates for the first option are shown in Table 13. For the second option the costs would be half of these estimates.

Table 13 Estimates of Social costs for 13-17 years assuming effects as in 0-12 years

Risk of death	Rate of risk reduction in asthma suffering	
	42% reduction	22% reduction
	Number of deaths	
1 in 10,000	0.7	0.3
1 in 5,000	1.3	0.7
social cost of deaths avoided ($ Million)		
1 in 10,000	2.30	1.21
1 in 5,000	4.60	2.41
Other social costs		
Affected number of asthma sufferers	6,575	3,444
Savings in financial costs ($ Million)	9.04	4.74
Total savings in social costs ($ Million)		
1 in 10,000	11.34	5.94
1 in 5,000	13.64	7.15

Source: NZIER

At 22% reduction (if cabinet heaters are replaced by non-polluting heaters), the additional savings in social costs would be between $6 million and $7 million per year (at the two low rates of death). This indicates a total social cost saving of $21-25 million per year with a mid point estimate of $23 million, for all children up to 17 years of age (Table 14).

At 42% rate, the estimate of social cost savings is in the range $11-14 million for 13-17 year old children and this makes the total for all children to about $39-47 million.

If we follow the second scenario, then the total savings for all children would be about $18-21 million and $34-40 million respectively for the above two cases, i.e., 22% and 42% reductions.

These provide us with a range of $18 – 47 million per year.

Table 14 Estimates of Social costs for all children

Risk of death	Rate of risk reduction in asthma suffering			
	13-17 years – same effect as <=12 years		13-17 years – half effect as <=12 years	
	42% reduction	22% reduction	42% reduction	22% reduction
Number of deaths				
1 in 10,000	2.27	1.19	1.94	1.02
1 in 5,000	4.54	2.38	3.89	2.04
social cost of deaths avoided ($ Million)				
1 in 10,000	7.95	4.17	6.80	3.56
1 in 5,000	15.90	8.33	13.60	7.13
Other social costs				
Affected number of asthma sufferers	22,721	11,902	19,434	10,179
Savings in financial costs ($ Million)	31.24	16.36	26.72	14.00
Total savings in social costs ($ million)				
1 in 10,000	39.19	20.53	33.52	17.56
1 in 5,000	47.15	24.70	40.32	21.12

Source: NZIER

The range of social cost savings per year if we consider only children up to 12 years of age is $15-34 million. For all children up to 17 years of age, the range of social cost savings per year amounts to $18-47 million. This large range is due to uncertainties in the effects as there is only limited information available.

These costs do not include any long term loss of life quality. That would arise if as a result of exposure to higher level of NO_2, the health effect remained worse than before the exposure. In that case, repeated exposure would gradually reduce the life quality of the asthma sufferer.

3.6.6 Summary of assumptions and limitations

The effects of NO_2 exposure are measured by several symptoms: wheezing, cough, waking up at night, visits to doctor for asthma, visits of pharmacist for asthma etc. There is only one New Zealand study (Howden-Chapman et al 2008) on measurement of these effects.

Considering that visits to doctor would indicate the severity of asthmatic conditions, we used doctor visits as a measure of health effects.

There are uncertainties on the level of cabinet heater and hence NO_2 exposure to asthmatic children. Different sources provide different figures. Considering all these sources, we have assumed that about 20% of households use cabinet heaters and there is no difference between households with and without children and also between households with and without asthmatic children.

Studies (Howden-Chapman et al 2008, Pilotto et al 2003, Nitschke et al 2006, Hansel et al 2008) show considerable variations in the effects of NO_2 on health of asthma patients. These studies provide a range of 22% to 42% change in asthma severities due to cabinet heaters in New Zealand. The estimate by Howden-Chapman et al 2008 and subsequent analysis is within this range.

The New Zealand study mentioned above (Howden-Chapman et al 2008) was confined to 6-12 year old children. We assume the effects would be the same for all children up to 12 years of age.

Studies show that higher level of NO_2 causes adverse effects of asthmatic children but no statistically significant relationship has been found for asthmatic adults (Pilotto et al 2003, Enhealth 2007).

We have considered two scenarios for children above 12 years of age, i.e., 13-17 year age group. In one scenario, we assume the effects would be the same as for up to 12 years of age. In the second scenario, we assume that the effect on 13-17 year age group would be half of that for up to 12 years of age. This we believe provides a reasonable range of effects on children.

There is only limited information on the risk of death from asthma. We started with the information provided in the Asthma Foundation website. This appears to be based on an old study and hence likely to be outdated. Another New Zealand study (Holt and Beasley 2001) shows that the rate of death is declining. It also shows that the risk of death is higher at older age. Taking these observations into account, we have estimated the savings in social costs if the risk of death is 1 in 10,000 and 1 in 5,000. This covers a reasonable range.

Severe conditions in asthma can result in death but it is not clear if that occurs soon after exposure to higher level of NO_2. The effect is unlikely to be immediate. So the yearly death statistics provide a reasonable risk level of this effect.

For the social cost of these effects we have only considered the likely loss of life and medical costs of non-fatal health conditions. We have assumed that there is no long term effect on asthmatic children.

The value of a loss of life to society is measured by the value of statistical life used in the transport sector which is based on a willingness to pay survey. The value is $3.5 million per premature death at 2009 prices.

The medical costs and costs of care givers are estimated as $825 million per year for 600,000 asthma patients noted in the Asthma Foundation website. This also appears to be based on an old study. It is not clear, if the same is still true, if the costs should be higher due to inflation or lower due to better knowledge of managing asthma. In the absence of better estimates, we have used this, i.e., $1,375 ($825 million/600,000) per year per asthma patient. If this is still the average, the cost is likely to be higher for children because they require more hospital admissions (Holt and Beasley 2001) and also they require more care-givers' time.

Studies also show that average loss of life quality due to asthma is in the order of 15% of normal life. This suggests that for 600,000 asthma sufferers in New Zealand, the total cost of loss of life quality is over $300 billion over the sufferers' lifetimes. For the asthmatic children exposed to cabinet heaters, this is about $20 billion.

Ignoring long term effects, if any, our estimate of savings in social costs by replacing cabinet heaters with non-polluting heaters are in the range of $15-47 million per year. The lower estimate of $15 million assumes no effect on children above 12 years of age. This is very unlikely. If the effect is at least half for older children, then the range would be $18-47 million.

A major limitation is that estimates have a wide range. The range can be reduced only with better information.

Besides, the estimates of social costs from use of cabinet heaters do not include the following which may have an impact on quality of health:

- The effects on adults
- Only asthmatic children have been considered
- There can be other respiratory problems
- The loss of life quality during the period of exposure and afterwards

If these could be included the estimated social costs would be higher.

3.7 Effects of household moisture levels

Moisture in the indoor atmosphere absorbs latent heat and increases the energy required to heat a given space. Such an effect should be reflected in the estimates of heating effectiveness such as those by CAE (2007) referred to in Table 4 above, so it does not need to be separately accounted for. What does need separate consideration is the external effects of moisture on occupant health and building condition.

Those consulted in this review were familiar with the linkage of cabinet heaters with moisture in the indoor atmosphere, as manifested in increased condensation on windows, growth of moulds, fungi and dust mites which can add to the aggravation of respiratory conditions, and damage to the buildings' structure and fittings such as carpets and curtains. Most were unspecific as to how much this could be attributed to cabinet heaters other than that they thought it significant, and some had an exaggerated view on how much moisture could be created by combustion of a given volume of gas.

For New Zealand's general LPG, which is a mix of butane and propane, on average there is 1.59 kg water produced from combustion of 1 kg of LPG. A 9 kg bottle contains 16.8 litres of LPG with a net calorific value of 410.9 MJ (114.2 kWh). To obtain 1 kWh of heat requires combustion of 0.079 kg (0.147 litres) of LPG and produces 0.125 kg (0.125 litres) of water. An unflued cabinet heater putting out 4 kW of heat in an hour would therefore produce 500 g (half a litre) of water an hour.

These results use information from MED's Energy Data File and other sources, and are broadly consistent with those in international studies. One of the few that looks in detail at sources of indoor moisture (Ten Wolde & Pilon 2007) found an unflued gas heater of 3 kW would add about 0.45 kg water per hour. These figures are based on natural gas which, being methane rich, produces about 20% more moisture than LPG so converting these results for the emissions from a 4kW LPG burner on full for an hour would be approximately 450g x 4/3 = 600 ÷ 1.2 = 500 g.

The international studies make it clear that the contribution of any one source of moisture inside the indoor environment is dependent on a number of site specific factors, such as the number of occupants in the house (including people, pets and houseplants which all transpire moisture), the amount of ventilation particularly in bathrooms, kitchens and laundry areas, and the underlying subsoil and associated water table. If unflued cabinet heaters are used infrequently and on a low setting for much of the time, adding 250 g of moisture an hour will be a relatively small contribution to total moisture generation at times when showering or meal preparation is taking place. They will make a proportionately more significant contribution to moisture if used at high settings or for long periods when other moisture generation activities are limited, and in the absence of adequate ventilation to remove moisture they can have more impact on lasting dampness.

In view of uncertainties over the uses of heaters and the location of houses that have them, there is no basis for determining the average contribution of unflued LPG heaters to moisture in homes, or in the associated costs to health and property.

4. The balance of costs and benefits

An economic cost benefit analysis attempts to estimate the value of benefits obtained from a given course of action to compare against the costs incurred from that action, in order to arrive at the balance or net benefit obtained from it. Such analysis attaches monetary values to identified costs and benefits to provide a common yardstick for comparison, and usually projects a stream of benefits and costs over the lifetime of the action to calculate lifetime net benefits in present value terms. Although cost benefit analysis employs techniques similar to those of financial analysis it differs from financial analysis in a number of ways, in particular in taking a national or community-wide viewpoint that takes account of not just the effects on a particular firm or entity, but also external effects on other affected parties in the community. It thus focuses on the question of whether the action is efficient for society at large in generating benefits that are more valuable than the costs incurred in achieving them.

Identification, quantification and valuation of the benefit and cost components are essential to such cost benefit analysis. Where data are deficient for quantification, assumptions can be made to fill in the gaps, and sensitivity analysis – changing the assumptions used for key variables – can be used to test the robustness of results. The foregoing sections have indicated that the statistics on the availability and use of cabinet heaters are fragmentary and difficult to reconcile across the different sources. Significant uncertainties exist around the magnitudes of some of the effects. Under such circumstances constructing a conventional cost benefit analysis on limited data runs significant risk of creating an impression of spurious precision and undue confidence in the results.

However, even analysis on incomplete data can be informative of where the balance of costs and benefits is likely to lie. In this review we start by identifying the value of costs and benefits from a year's use of cabinet heaters, as a prelude for considering what the balance of costs and benefits is for the year and how it is likely to change over time.

4.1 Defining the counter-factual

A first step in cost benefit analysis is in defining a "counter-factual", or situation that would prevail in the absence of the action under examination. As this review is concerned with the costs and benefits of cabinet heaters in New Zealand, the counter-factual is the situation that would prevail in the absence of such heaters in New Zealand. This is similar to banning the use of these heaters, but not identical as there would be implementation costs to consider in assessing such a ban.

The key issue in defining the counter-factual is deciding what people who use cabinet heaters would use instead if they were not available. This requires consideration of the benefits that cabinet heaters provide, and considering what substitutes might be available in obtaining those benefits in other ways. The benefits of cabinet heaters are:

- A source of heat that is
  - Controllable and readily variable in output
  - Capable of rapidly warming a space
  - Portable, both within a property and between properties
  - Relatively low cost in acquisition of the appliance
  - Capable of pre-payment for budget management purposes
  - Independent of reticulated supplies that may be interrupted, either because of natural events or because of budgetary mismanagement and disconnection.

These benefits all stem from reducing the risks of being cold and uncomfortable that may have various causes. This is a broad range of benefits that is not matched by any other heating appliances currently on the market. The main options are:

- Flued gas appliances, which need to be fixed installations and hence lose the benefits of portability, low cost acquisition, one-off prepayments, and (with the exception of large bottled gas systems) independence of reticulated supplies that may be interrupted (as occurred in Victoria in 1998 when a fire in a distribution plant took out state-wide natural gas supplies for two weeks)
- Heat pumps, which are also fixed installations and hence lose the benefits of portability, low cost acquisition, one-off prepayments, and independence of reticulated supplies that may be interrupted or constrained (as occurred in dry hydro years in 2001, 2003 and 2008, and periodically occurs in scattered localities following winter snow dumps, particularly in rural areas where lines are long and exposed and take a long time to repair)
- Solid fuel burners, which are also fixed installations and hence lose the benefits of portability, low cost acquisition, and readily controllable heat output (with significant home labour cost in operation), but do provide ability to pre-pay for fuel and independence from reticulated energy supplies
- Electric plug-in resistance heaters, which share the portability benefits of cabinet heaters but are not independent of reticulated supplies and also seem to be regarded by some as a different, less rapidly warming heat.

Prior to the introduction of cabinet heaters in New Zealand mobile unflued heaters burning kerosene or alcohol were used in domestic settings. These had a reputation for smokiness, contributed to indoor air pollution and fire risk and were not as convenient to use as cabinet heaters. If cabinet heaters were not available today it is possible that such devices might make a comeback, but these heaters had been in long term decline before cabinet heaters arrived, displaced by cleaner electric heaters, and they are unlikely to have a significant presence in the counter-factual.

The closest substitute for cabinet heaters appears to be electric plug-in resistance heaters, including radiant bar heaters, convection heaters, fan heaters and oil filled radiators. These are not perfect substitutes, however, and a world without cabinet heaters would be one without some of the functionality that these cabinet heaters provide.

4.2 The value of benefits of cabinet heaters

That a sizeable share of the population are willing to pay to acquire and use cabinet heaters is indication that they value the combination of benefits they provide. That willingness to pay amounted to about $84 million in 2008 (Table 7). That value consists of the costs that consumers incurred for the fuel for use of cabinet heaters that year, excluding the costs of ownership of the cabinet heaters. Although that is a cost to consumers, it is also a lower bound measure of the value they get from heaters, as the benefits must be worth at least as much to them as they are demonstrably willing to pay for them. As some consumers would be willing to pay more than they actually do and obtain a bargain price, the difference between what they do pay and what they would pay if they had to also means there is a consumer surplus on current use of cabinet heaters.

The estimate in Table 7 is based on an annual consumption in 2008 of 296 GWh across households with cabinet heaters. If all these households had to obtain the same heat from electric resistance heaters, the volume of electricity consumed after allowing for transmission losses would be 319 GWh per year. However, consumer prices already allow for transmission losses, so the cost consumers would incur for power at 24 c/kWh would be about $71.1 million for the same collective heating load (296 GWh @ 24 c/kWh). In other words, households that use cabinet heaters could get the same heating load for $13.1 million less than they currently do. That they do not give up their cabinet heaters implies that benefits other than portable kWh of heat – rapid warm up, pre-payment capability, and independence from reticulated supplies – are worth the extra cost of using cabinet heaters. That is the identifiable benefit of the cabinet heaters over the counter-factual.

These estimates are all inclusive of GST, consistent with those in tables 4, 5 and 6. Although GST is part of the financial cost faced by individuals, from a national viewpoint it is a transfer payment between consumers and government and is usually excluded from cost benefit analysis. Excluding GST, the cost of 28.4c/kWh for LPG heat would be 25.2 c/kWh, and the 24 c/kWh cost of electricity would be 21.3 c/kWh. Across a range of LPG prices, the comparison with the cost of electricity for equivalent heating energy is illustrated in Table 15 below.

Table 15 Comparative cost of LPG and electric heating

		Low	*Medium*	*High*
Cost/ 9kg LPG (GST Inclusive)		$ 32.40	$ 33.50	$ 35.00
Cost/kWh LPG (GST inclusive)		$ 0.284	$ 0.293	$ 0.307
GST exclusive				
GWh/yr LPG		296.3	296.3	296.3
Cost/kWh LPG		$ 0.252	$ 0.260	$ 0.273
Total cost/year LPG	$M	74.763	77.177	80.864
GWh/yr Electricity		296.3	296.3	296.3
Cost/kWh Electric		$ 0.213	$ 0.213	$ 0.213
Total cost/yr Electric	$M	63.216	63.216	63.216
Premium LPG over electric $M		**11.547**	**13.960**	**17.648**

Source: NZIER

The economic value of the benefit of cabinet heaters, over and above the next most likely alternative (electric plug-in), is in the range of $11.5 million to $17.6 million per year, plus the (unquantified) surplus to those consumers who would have paid more than they actually did.

4.3 The value of costs of cabinet heaters

4.3.1 Supply costs

The supply costs of cabinet heaters and their next most likely alternative consist of the private costs of the owners of these appliances, both acquisition cost and running cost, and the costs of infrastructure used in supplying energy to these heaters. As both LPG and electricity are supplied on a commercial basis, the infrastructure costs are covered by the costs incurred by users for their fuel, so do not need to be considered separately if reflected in current pricing.

The fuel cost differences between the unflued LPG cabinet heater and the electric plug-in heater is the same calculation as for the benefit: although these are costs they are also expressions of the relative willingness to pay for the different types of heater, and hence of the benefit of the cabinet heater over its alternatives.

For a typical unflued LPG cabinet heater of 3.5-5 kW output we assume an acquisition cost (including a 9 kg bottle) of $180 ($160 GST exclusive). While plug-in heaters can be purchased for less than $100, they are limited to a maximum of 2.4 kW output, so it would require two such heaters to provide equivalent heat output to a cabinet heater.[25] Given the variety of electric heaters available and the futility of

[25] While cabinet heaters appear to be used at low settings for much of the time so that their average heat output might be met by a single electric plug-in heater, they have the capability and are used for higher heat output when required, so a single electric heater is insufficient as an “alternative”.

seeking precision, we assume there is no difference in acquisition cost for the two types of heater (i.e. 2 electric heaters giving 4.8 kW output can be purchased for $160 excluding GST). But electric heaters have a shorter life span of 7.5 years compared to the cabinet heater's 10 years, so on an annualised cost basis the cabinet heater is about $5.40 cheaper per year. If there are 450,000 cabinet heaters in New Zealand (both residential and non-residential) this would imply an annualised cost advantage of $2.42 million in having cabinet heaters over electric plug-in heaters.[26]

A further cost of ownership is maintenance, which for unflued LPG heaters is recommended to be undertaken annually and costs around $45 ($40 GST exclusive). From consultation and other sources it is clear that very few heaters are professionally maintained on an annual basis: the modal frequency is probably around two years, and the mean interval between maintenance across the heater stock is longer. If the mean frequency is one professional check up every five years, this would be an annual cost to unflued LPG heaters of $8 GST exclusive per year each.[27] Electric plug-in heaters need virtually zero maintenance by comparison. In aggregate, 450,000 cabinet heaters would incur an annual cost of $3.60 million over and above that for alternative electric heaters.

A further supply cost arises from the potential for additional loading on the electricity system to impose costs that do not appear in current prices. As discussed earlier, if cabinet heaters were not available and their 296-360 GWh aggregate power output were replaced with equivalent output from electricity, this would add 2.4-2.9% to residential electricity consumption and may necessitate either increased high cost generation at the margin (probably thermal generation, with extra greenhouse gas emissions) or bringing forward the date of investment in new generation and transmission capacity. As we do not know the distribution of LPG cabinet heater use around the country it is not possible to calculate these effects, but by avoiding the earlier investment in the electricity system LPG cabinet heaters also avoid some costs that would be incurred by use of alternative electric heaters.

In summary, therefore, the energy supply effects of LPG cabinet heaters against the alternative of electric heaters are:

- A saving in acquisition costs annualised to $2.42 million per year
- Additional maintenance costs of $3.60 million per year
- A saving (unquantified) in electricity system investment costs, representing the present value of not bringing forward investments to meet increased demand from electric heater use.

[26] This is based on annualising the $160 cost of cabinet heaters and electric heaters over 10 years and 7.5 years respectively, at a rate of 3%.

[27] While it might be argued that maintenance costs should reflect the recommended annual frequency for all heaters, cost benefit analysis needs to reflect expected actual behaviour, rather than a hypothetical standard that is not being met. The aggregate maintenance cost may be more or less than $3.6 million per year, but is unlikely to be as much as $9 million per year, which would result if all cabinet heaters were maintained once every two years at $20 per year each.

The net effect of acquisition and maintenance is a cost from using cabinet heaters of $1.18 million, less the unquantified saving in electricity system investment deferral.

4.3.2 Greenhouse gas emissions and outdoor air quality

LPG is a fossil fuel so its combustion is associated with greenhouse gas emissions. If LPG heaters did not exist these emissions would be eliminated, but replacing them with electric heaters would also result in emissions from electricity generation.

Currently New Zealand obtains about 65% of its electricity from renewable sources of hydro, geothermal and wind generation, but marginal generation to meet additional loading commonly comes from thermal plant fired by gas or coal. These plant have higher emission rates than burning gas directly, because of energy lost in transformation from fuel to electricity. For instance, coal emits about 91 kilotonnes of CO_2 equivalent (CO_2–e) per petajoule of energy and natural gas emits about 57 kilotonnes. But the conversion efficiency of a coal fired plant is about 0.38, and that of a gas fired plant is about 0.54, which means per petajoule of electricity their respective emissions would be 240 and 106 tonnes CO_2–e. By comparison the emissions per petajoule from burning LPG directly are about 66 tonnes CO_2–e.

On this basis the current annual LPG heater use of 296 GWh emits around 70 kt CO_2–e, but after allowing for 7.5% transmission and distribution losses, the equivalent delivered energy from gas fired generation plant would emit 121 kt CO_2–e. The emissions from equivalent output of a coal fired plant would be 275 kt CO_2–e. At present marginal electricity generation is met by a mix of coal, gas and sometimes hydro generation, but the latter tends to be used sparingly as it has higher value stored for later use. On balance, therefore, the emission rate of gas fired generation is a reasonable mid-point for greenhouse gas emissions from marginal generation when replacing LPG cabinet heaters with electric heaters.

The value of carbon credits for offsetting against greenhouse gas emissions has undertaken a volatile ride in recent years, with values exceeding $30/tonne CO_2-e prior to 2008 but dropping sharply during the credit crunch, to a low from which they are only slowly recovering. Currently credits for delivery in December 2010 on the European Carbon Exchange are around €15 per tonne CO_2–e, which at today's exchange rate equates to around NZ$30. The New Zealand Treasury's latest assessment of New Zealand's Position under the Kyoto Protocol in February 2010 posits a lower carbon price of €10.75, equivalent to NZ$21, per tonne CO_2–e. So replacing the current 296 GWh of LPG cabinet heaters with electric heaters is likely to increase greenhouse gas emissions from 70 kilotonnes to 121 kilotonnes, an increase of 51 kilotonnes with a value at current prices of around $1.0 million (at Treasury's prices) or $1.5 million (at current market prices).[28]

[28] Current government policy is to cap the carbon price at $12.50 per tonne CO_2-e until 2012 but this does not change the cost to the nation of greenhouse gas emissions: under the Kyoto Protocol government is responsible for ensuring New Zealand's carbon credits match its emissions over the 2008-2012 period, so government bears the cost of any difference between international market price and the value it receives for emission units it places in the local capped market.

This means there is a benefit for greenhouse gas emissions from not replacing cabinet heaters with electric heaters, which can either appear as a "negative cost" or be placed on the benefit side of the ledger.

Apart from greenhouse gas emissions, cabinet heaters can also improve air quality to the extent they displace heating by wood or coal burners that have higher particulate emissions. High use of solid fuel is associated with poor outdoor air quality in locations such as Nelson and Christchurch, and regional councils have used regulations and subsidies to replace solid fuel burners with cleaner heating appliances. Air quality problems are generally associated with urban concentrations, and in absence of data on the distribution of cabinet heaters it is not possible to quantify their contribution to alleviating such air quality problems.

4.3.3 Accident and safety risk

The economic value of accidents and safety risks from cabinet heaters was estimated earlier as an average of $2.4 million per year (see 3.5.4). This was estimated fatalities, injuries, and property damage drawn from records of incidents related to cabinet heaters, and valued using processes developed for use in transport appraisals but also widely applied in other situations for assessing the social cost of accident and safety risks.

Fire service records show the fire risk of cabinet heaters to be greater than those of electric heaters: for cabinet heaters over the period 2001 to 2009 there have been on average 6.2 incidents per 100,000 heaters, compared to 2.3 incidents per electric heater on average. If it is assumed that the incident rate with an electric heater is 37% that of an LPG heater, replacing cabinet heaters with 2 electric heaters of equivalent output would result in expected social costs of 74% those of the cabinet heaters, i.e. $1.7 million per year. Therefore the cost of using cabinet heaters relative to the counter-factual of electric heaters is $0.62 million per year.

4.3.4 Health and quality of life risk

The risk to health and quality of life of cabinet heaters arises from emissions of NO_2 and water vapour that can foster moulds and dust mites that are irritants to those with respiratory disease. A principal concern with these heaters is the effect on those with asthma, particularly children, on whom the observed effects of these irritants has been most pronounced.

The reduction in social cost of health and quality of life risk to asthmatic children up to age 12 across New Zealand has been estimated above at between $15-34 million a year based on reduction in NO_2 emissions and two overseas estimates of likely health effects from such reduction (section 3.6). A separate estimate based on a 30% reduction in doctors' visits in New Zealand (Howden-Chapman et al 2008) would imply a social cost of $20-24 million a year. There is no definitive evidence on the long term effects of indoor air quality i.e. whether there is a cumulative deterioration in asthma condition from exposure to NO_2 which would be reduced by removing unflued heaters, rather than just a reduction in asthma attacks with primarily short term effects.

With those provisos a figure of $23 million per year appears more likely to err on the conservative side.[29] However, these estimates are based only on effects of children under the age of 12, for which statistically significant effects of NO_2 have been observed. We have found no reports demonstrating statistically significant health impacts for adults, but it is conceivable that other age groups could face adverse health effects – e.g. those in the near-childhood age groups of 13 to 17. Omitting other age groups from our estimates also tends to make them conservative. The literature mainly emphasises worsening effects of NO_2 on asthma patients, where no statistically significant effect has been established for adult asthma patients. For other respiratory diseases, we have not come across any study showing a dose response relationship with NO_2 on quality of life for adults or the risk of death due to exposure to higher level of NO_2 when one is suffering from respiratory diseases other than asthma. This does not rule out the possible impacts on these people, but it is unlikely to be large enough to have substantial impact on the study outcome.

Adding children up to age 17 would raise the estimates range to $18-47 million per year. For the cost benefit analysis we use central estimates of $23.4 million for 12 and under and $9.5 million for older age groups, with combined cost of just under $33 million per year. But we also show the effects of health costs being $18 million or $47 million per year.

4.3.5 Building operation and maintenance cost

Despite much discussion with consultees about the moisture output of cabinet heaters, the likelihood of increased cleaning of fabrics to deal with moulds, replacement of rotting carpets or repairing of paintwork or structural components, we have not discovered any hard evidence on the generalisable economic costs of additional moisture loading on indoor atmosphere attributable to cabinet heaters. While there is probably some cost in some circumstances, it is not clear whether on average across the population of buildings with such heaters that it would be significant, so no attempt has been made to quantify it here.

4.3.6 Summing up the cost benefit analysis

Bringing the above estimates together, in 2008 the net effects of cabinet heaters, relative to a next most likely alternative of electric plug-in heaters, were:

- Benefits of $15.0 million, reflecting users' willingness to pay more than they needed to for the same heat output as from electric heaters plus the value of lower greenhouse gas emissions

[29] There is some uncertainty around these estimates because they rely on a study of removing cabinet heaters from New Zealand homes, the results of which may be reflecting the effects of improved heat in the home - with temperatures in living areas increased by slightly over 1^{o}C and bedroom areas increased by over 0.5^{o}C – rather than improved air quality from reduction of moisture and NO_2.

- Costs of $34.7 million, comprising
  - $1.18 million of additional operation and maintenance cost for LPG heaters
  - $0.62 million of additional cost of accident and safety risk
  - $32.6 million of additional cost for health effects to asthma sufferers
- Other identified benefits and costs that were unquantifiable include
  - Additional benefit from cabinet heater use from consumers' surplus for those users who would have paid more for their preference for heaters if they had to
  - Additional benefit from avoiding the cost of bringing forward electricity generation and transmission upgrades to meet additional electricity demand
  - Potential additional costs from long term effects of exposure to CO, NO_2 and other triggers for asthma attacks, and for other age groups than the under 12s
  - Potential additional costs for countering the effects of moisture from unflued gas combustion on the maintenance of building structures and fabrics
    - These could potentially be measured if maintenance costs can be associated with incremental contribution of unflued heaters to moisture, but indoor moisture is dependent on a number of contributory factors and it is hard to generalise about moisture attributable to unflued LPG heaters
    - Alternatively the cost of removing moisture from unflued gas combustion with a dehumidifier could be estimated, but this can only be related to the real costs of such moisture if the incremental contribution of unflued heaters is known.

From the quantifiable results above, the availability of cabinet heaters across New Zealand appears to have had a quantifiable benefit of $15.0 million but quantifiable costs of $34.7 million in 2008, resulting in a net cost of $19.7 million and a benefit cost ratio of 0.4.

These results are summarised in Table 16 below, showing both the central estimate (based on 30% reduction in doctor's visits) and a low and high estimate based on NO_2 effects on health. The low health cost estimate gives a benefit cost ratio of 0.8, the high estimate a ratio of 0.3.

These estimates are also based on the Treasury's current value for carbon of around NZ$21/tonne CO_2-e. Using the current market price from the European Carbon Exchange of around $30/tonne would add about half a million dollars a year to benefits, but with negligible effects on the benefit cost ratios.

The results cannot be regarded as conclusive, but they are suggestive of some significant economic costs on health and environment that are outside the visible transactions of appliance and fuel purchases. The table also identifies some significant gaps in the analysis and the likely sign attached to them, but makes no comment on how substantial they are likely to be. The results are strongly driven by the values for preference for LPG over alternatives, and the value of health effects.

Table 16 Benefits and costs of cabinet heaters compared to alternative electric plug-in heaters

Estimated 2008 LPG cabinet heater output of 296 GWh; GST exclusive

	Central $M/year		Low $M/year	High $M/year
Value of benefits of heating	13.96		13.96	13.96
Consumer surplus		? Positive		
Greenhouse gas emissions	1.07		1.07	1.07
Electricity investment saving		? Positive		
Total benefit	15.03		15.03	15.03
Costs of suppliers/infrastructure	-1.18		-1.18	-1.18
Costs of fires & CO risk	-0.62		-0.62	-0.62
Costs of health effects: under 12s	-23.37		-14.59	-33.50
Costs of health effects: other ages	-9.52	? Negative	-2.97	-13.64
Costs of moisture loading		? Negative		
Total social cost	-34.69		-19.36	-48.94
Net benefits	-19.66		-4.33	-33.91
Benefit cost ratio	0.4		0.8	0.3
Annual national heating output GWh	296		296	296

Source: NZIER

These estimates are all based on a mid-range value of LPG of 26 c/kWh GST exclusive (equivalent to a bottle refill cost of $33.50 GST inclusive). Using a top of the range value of LPG of 27.3 c/kWh (equivalent to a bottle refill cost of $35 GST inclusive) the benefit cost ratio on the low health estimate rises to 0.9, but with the other health estimates the ratios do not rise above 0.6.

Table 17 shows the variation in benefit cost ratios with changes in LPG price assumption and health cost estimates, with the bottom half of the table showing how much LPG use would be required to achieve a positive net benefit from the analysis. If the heat output of LPG heaters were slightly higher, say 310 GWh or above, and the price of LPG was high, net benefits on the low health estimate would turn positive, holding other things constant. Conversely any further decline in heat from the 2008 level would make the result more negative. With the medium LPG price assumption, LPG output would have to rise to 370 GWh per year to achieve a positive net benefit with the low health estimate, a little over the level of cabinet heater use in 2005. On the low LPG price, LPG output would need to rise to 470 GWh per year, well above the level of cabinet heater use achieved in recent years. However, the accident and health costs would not stay constant but vary with the exposure to additional risks from increased cabinet heater use. This variation cannot be modelled without stronger assumptions about the distribution of those at risk than can be inferred by available data. In cost benefit analysis it is normal to use a benefit cost ratio greater than 1 to determine net benefit when there are large uncertainties in the estimates, so these results illustrate that the benefits of cabinet heaters would need to be substantially higher than those calculated here to achieve a net benefit of sufficient margin to outweigh the uncertainties in the data.

Table 17 Variation in benefit cost ratios with price and health cost estimates

LPG Price $/kWh		GWh/yr	Health cost estimates		
			Low	Central	High
$	0.252	296.3	0.7	0.4	0.3
$	**0.260**	**296.3**	**0.8**	**0.4**	**0.3**
$	0.273	296.3	0.9	0.6	0.4
$	0.252	470.0	1.0	0.5	0.4
$	**0.260**	**370.0**	**1.0**	**0.5**	**0.4**
$	0.273	310.0	1.0	0.6	0.4

Source: NZIER

It is assumed in these rough estimates that the health costs do not increase with GWH per year. That would be the case only if the additional heaters are used by non-asthmatic people and also they take enough care to avoid fire and other risks of accidents. While such a possibility may exist, it should normally not be expected.

4.4 Future directions of costs and benefits

A quantified cost benefit analysis will normally project annual streams of costs and benefits over time and convert the figures to present values to arrive at a lifetime net benefit. In this case, given substantial uncertainties, such a process could be misleading. However, with respect to future directions for LPG heater use, the infiltration into the housing stock of heat pumps and other more efficient heating seems likely to continue, and with the recent decline in use of LPG cabinet heaters in the main part of houses it is unlikely that they will regain the proportional significance that they formerly had, even if the recent rise in LPG prices is reversed. As their use declines, so too do their benefits and the exposure to risks that they pose.

4.5 Caveats around these results

There are a number of caveats around these results, due largely to the limitations of data. It is also possible that other counter-factuals could have emerged in the absence of cabinet heaters: some households might invest in other heating devices than electric plug-in heaters, incurring greater up front costs but lower on-going costs in the process. Some households, particularly those on lower incomes, might simply make do with less heat, and become susceptible to more cold related disease.

An assumption in the estimates here is that cabinet heaters and asthma are evenly distributed (sections 3.6.2a and 3.6.3) but this may not be the case. For instance, Census data in Table 2 above show that the Wellington region has one of the lowest percentage shares of total dwellings with bottled gas, whereas *The Burden of Asthma* report shows Wellington to have among the highest reported proportions of wheezing and asthma in 6-7 year old children (Holt & Beasley 2001, Table 2, p. 5). A change in the availability of cabinet heaters may therefore affect the incidence of asthma to different degree than suggested in these estimates, but without better data it is not possible to identify how much difference this even distribution assumption makes. Also while there may be substantial regional differences, the difference may be small at the national aggregated level.

Other caveats around these values include the following:

- The extra cost of LPG heating as a benefit: that there is extra cost for a given heat output from LPG heating compared to electricity is readily quantifiable, but counting it as a benefit depends on it representing a willingness to pay extra for the attributes of LPG cabinet heating. If consumers use LPG in the mistaken belief it is cheap – and there is evidence from surveys and consultation that at least some do – then it can hardly be described as an informed preference for the more expensive form of heating. However, as LPG cabinet heaters have attributes that are not matched by electric heaters – independence from interruptions to reticulated supply, the ability to pre-pay for energy – it is unlikely that all LPG users are "mistaken" and a substantial part of the extra cost of LPG is likely to reflect real preference.
- Lower greenhouse gas emissions from direct LPG combustion than from conversion of gas or coal into electricity is a firm result, at least in the short term: how much generation at the margin comes from gas, coal or hydro is open to question but at present marginal generation is more likely than not to be thermal-fired. In the long term this likelihood of thermal may reduce as new renewable generation plant are built.
- Value of health costs: these rely on the results of a single study of heater substitution that identified health improvements from replacing LPG heaters with more effective heating systems than just electric plug-in heaters, so the health benefits may reflect greater gains in home heating than in the counter-factual in this assessment. This may result in some over-statement of health costs in this assessment; conversely health costs may be understated by the lack of data to quantify increased risk of developing asthma in infants and the exacerbation of other respiratory conditions that are affected by NO_2 in all age groups.

In the quantified analysis, the willingness to pay extra for LPG dominates the benefit side of the ledger and the health costs dominate the cost side. Testing the sensitivity of results has concentrated on variations in these two items, which far exceed the other quantifiable effects.

A number of issues emerge around the findings of this review. The public health sector is unequivocal that exposure to unflued gas heaters increases respiratory symptoms in children, and that the cost of health effects in this review is understated because it does not cover costs to adults with asthma or other respiratory diseases, nor the potential of children developing respiratory conditions because of exposure to NO_2. Commentators have challenged the view that cabinet heaters are safe if maintained and used according to manufacturers' instructions, citing evidence (such as enHealth 2007) that indoor air pollution regularly exceeds safe levels in homes where unflued gas heaters are used in real life situations. They have also suggested the record of cabinet heater safety incidents is understated because of mis-reporting of hospital admissions for CO poisoning.

It is clear that the quantified cost benefit analysis cannot be regarded as "precise", given the nature of the data available. In preparing such analyses there is rarely ever complete information and analyses must be made on the data available and informed assumptions. In this case the information and data on health effects of the combustion products of LPG cabinet heaters only report significant impacts on health of asthmatic children and record no significant effect on other age groups. This does not mean there is no effect on other age groups, and the quantified cost estimates in this review have been enlarged by assumption to include older children up to 17 years old. But there is no basis for presuming health effects on other age groups are large and widespread enough for cabinet heaters to pose a health risk to the general population rather than to a minority with pre-existing condition.

Safety risk may be under-reported, but the number of recorded incidents is so low that it would take a major correction in fires or CO poisonings attributable to cabinet heaters to have an appreciable effect on the cost benefit results. On the benefit side, although the perception of LPG as a cheap fuel is widely referred to by commentators, there is no evidence that all, or even most, LPG users are mistaken in their views of its cheapness and are uninformed about their heating choices. The ratio of benefits to costs other than health costs in this analysis is in excess of 10, and it would take a very large correction to accident under-reporting, or a very high proportion of cabinet heater users who pay more for energy than they need to on the mistaken belief it is cheap, to overturn that ratio. That suggests that if health costs can be eliminated by targeted measures, there would be no incremental benefit in extending interventions across the remainder of the population who are less susceptible to risks to health.

This means that the major costs dominating the cost benefit balance are focused on a sub-set of the population, and that measures targeting that sub-set are more likely than general untargeted measures to reduce the risks of cabinet heater use without depriving the less susceptible of the choice of obtaining the benefits they provide. That conclusion depends on there being cost effective targeted measures available, which needs to be determined by close analysis of specific options.

4.6 Implications of results

The quantified cost benefit analysis suggests there are substantial health costs associated with the use of LPG cabinet heaters, far larger than recorded safety costs and the estimated benefits obtained from them. The adverse effects on quality of life associated with raised NO_2 emissions could make those health costs far higher still.

However, LPG cabinet heaters have certain attributes – such as rapid heat capability and independence from interruptible reticulated supplies – that mean there are no exact substitutes for the benefits they provide. The quantifiable health costs apply to a minority of the population – albeit a sizeable one – so if the susceptible subset of the population could be removed from exposure to the effects of cabinet heater use, the health costs would diminish and cabinet heaters could be used by the less susceptible and be net beneficial for the nation at large.

It might be argued that the health costs of cabinet heaters are so large as to warrant a general intervention to reduce them. There are many interventions made on health and environmental grounds that benefit only a part of the population. For instance, removing the lead from petrol was based largely on demonstrated adverse effects on children's health and brain function, and similar justification has been used for removing lead from paint and other products. However, in these cases the intervention is aimed at an unambiguous externality, a generalised adverse effect that is borne unwittingly by third parties because it pervades the environment and cannot be avoided.

In the case of cabinet heaters, however, the adverse effects are primarily borne by an albeit sizable minority of the population with susceptible respiratory conditions, and are also localised within the households that make the decisions to use cabinet heaters. While there may be externalised effects of ill-health and accident in terms of disruption to others' work patterns and medical costs shifted to the tax-funded health system, the principal effects (loss of life and life quality) are internal to the households in which the susceptible subset of the population resides where decisions on heater choice are made. That is not a generalised externality, and attempts at finding cost effective targeted measures need to be exhausted before considering more generalised measures that will affect those who gain nothing from them yet bear some cost from their imposition.

Some options for reducing the costs without undue deprivation of the benefits are considered in the following section.

5. Options for improvement

5.1 Reasons for intervention

In considering options for improvement in managing the effects of cabinet heaters it is necessary to have a clear rationale for why intervention might be required. Government action commonly centres around achieving a number of public benefits, such as:

- Protection of public health and saving health sector costs
- Protecting vulnerable populations
- Protecting children and the investment in their education
- Protecting the housing stock across society.

The economic rationale for intervention is more narrowly focused on improving the efficiency or equity of the use of society's resources, by correcting market failures, government failures or improving resource re-distribution. This focus provides some guide to the nature of the problems and the level and type of intervention that would be consistent with interventions in other policy areas. This in turn sits within the wider aim of efficiency across interventions which would be indicated by a similar social return on interventions across the full range of policy interventions, i.e. achieving a policy mix where it is not possible to divert resources from one intervention to another to achieve a better outcome. A cost benefit analysis is an attempt to enumerate such returns from policy-induced changes in outcomes across the community.

The quantified cost benefit analysis suggests cabinet heaters are likely to have costs greater than the benefits they provide, so applying cost effective ways of reducing those costs would be net beneficial for New Zealand. This means finding measures that do not create more costs than they solve, and are not unduly burdensome on those who have no influence in the problem being addressed.

5.1.1 Application to cabinet heaters

Cabinet heaters are not the cheapest form of space heating if used safely with appropriate level of ventilation, but this in itself is not a reason for policy intervention. What is the best heating option to use in a given situation depends on more than just the cost per kWh of heat, and such decisions on heating have been left to individuals themselves who are regarded as being in the best position to optimise heating choice in light of their heating needs and financial circumstances. Cabinet heaters are a heating option with certain characteristics – portability, non-reliance on reticulated power or gas supplies – that are not matched by more energy efficient options. If they were not available there would be a loss of functionality in heating choices. They provide a contribution to energy choices which would need substantial demonstrable social cost to warrant their removal from the energy mix.

A source of such social cost comes from market failures, and in particular the "externality" effects on air quality and safety risk within and outside the buildings in which they are used. The effects of cabinet heaters, however, are not classic "externalities" in the sense of adverse effects falling on unwitting third parties to those whose decisions create them, because health impacts are primarily incurred by the households that use these heaters. Although there are genuine externality effects from their use, such as health costs borne by general taxpayers rather than the users of heaters or the productivity disruption of individual's ill health on those around them, an externality argument for curtailing use of heaters is only unambiguous for situations where third parties are affected, such as schools and hospitals where in any case more effective heating options should be feasible.

Another source of externality is that the fire risk and moisture related damage to house structure in rented accommodation is borne by landlords. Without direct control over use of LPG cabinet heaters they may bear cost for tenants' benefit. Unlike health costs these risks are borne across the whole population of cabinet heater users, but are small in relation to cabinet heaters' estimated benefits.[30]

A variant of market failure is information failure, in which the conditions of a market mean that insufficient information is made available on the relative merits of a product so that inefficient decisions are made as a result. Information failure commonly occurs when information is not created or disseminated because suppliers of that information would not be able to recover their costs of supply. It may also occur if information suppliers are unable to deliver their information to those who may act on it in a form that they can act on, again because the costs of so doing are higher than they can expect to recover.

Documented survey results show that there is widespread misinformation about cabinet heaters, about their relative cheapness to run, the "dryness" of the heat they provide, and the level of maintenance and ventilation required for safe operation. Although information is publicly available on websites and through promotional campaigns, awareness of these sources appears to be low. Information failure is not so much on the provision of information, as on its dissemination and effectiveness in changing behaviour. Other than brief reference to recall of safety measures in a survey of cabinet heater users (Fryer et al 2006), there appears to have been little analysis of the effectiveness of information provision or how it might be improved.

Government failure can occur when government actions create incentives that result in adverse consequences, for instance where attempts to "correct" market failures result in other problems that may be more intractable than those they set out to reduce. Cabinet heaters fall outside the ambit of controls over installation that apply to most other gas appliances which are fixed, and appear to sit within a regulatory crack, with safety regulation focused on reducing the risk of immediate injury and fire rather than the longer term health effects from prolonged and inappropriate use.

[30] Some economists would argue that risks of accidents are not externalities but are internalised in the decisions of cabinet heater users, but this depends on the assumption that users have perfect information on the risks and bear the costs. In practice at least some costs are borne externally through insurance and collectively funded fire services.

5.1.2 Pointers on policy for cabinet heaters

The critical issue is that from the record of incidents, these cabinet heaters do not appear inherently unsafe or unhealthy if used with the recommended precautions, but they may be if not used properly. Although the rate of incident has been low over most of the last 17 years, there has been an increase in recent years which raises questions over whether this is just a case of random statistical bunching or evidence of some greater underlying problem. While having a concentrated store of energy linked to an appliance through a valve connection will always carry some risk of leakage and accident, many of the reported incidents appear to be caused by users' behaviour rather than appliance fault. Regulating their use to reduce risk of incidents requires changing people's behaviour on a sustained basis.

The statistics on cabinet heaters are fragmented and it is difficult to reconcile some of the sources. This review has revealed some differences between the perceptions around the uses of LPG cabinet heaters and what the statistics say.

- There is some confusion around the broader terms "bottled gas" and "unflued gas" with the smaller subset of cabinet heaters, which has led to some exaggeration around the prevalence of cabinet heaters. From this review it seems likely that:
  - There are 450,000 to 500,000 cabinet heaters in New Zealand
  - They are found in around 310,000 households (21% of total), but in the main living area of a smaller number of households
  - Around 10% of these households could have more than one cabinet heater
  - The balance of heaters would be in workshops and commercial properties like shops and restaurants, where air-space is greater and individuals' exposure to harmful effects is less
- Cabinet heaters are probably the most numerous type of gas appliance in New Zealand, occurring in more households than natural gas or reticulated large bottle gas systems
- LPG provides about 2% of residential energy use, mostly through unflued cabinet heaters. Among households with such heaters, LPG on average provides about 950 kWh energy per year, around 24% of the average household energy use on space heating
- Their aggregate nationwide energy contribution of around 300-360 GWh a year in recent years is equivalent to around 2.5-3% of household energy consumption, and for around 12-17% of total LPG consumption
  - Replacing this energy with electricity has implications for bringing forward the date of new infrastructure capacity investment unless phased in gradually
  - Reducing the LPG consumption from this source would have little effect on overall LPG supply and distribution, other than reducing imports
- The common association of these cabinet heaters with those on low incomes is not borne out by statistics

- The proportion of these heaters found in households in the lowest income groups is about half the proportion of these income groups in the population at large
- Both middle and higher income groups have a higher proportion of these cabinet heaters than their respective proportions of the population at large
- The proportion of cabinet heaters in rented accommodation is about the same as the proportion of rented accommodation in the total housing stock

- The average LPG use per household is highest in the South Island, where temperatures are colder and there is no reticulated natural gas supply.

In view of this, measures prompted by concerns for the vulnerable, the elderly and those on low incomes are not likely to be relevant to the majority of households with such heaters. This raises questions around how much opportunities for the majority can be restricted for the benefit of minorities. If incidents around heater use are primarily related to their improper use, the effective responses would target the causes of that improper use rather than apply broad measures that curtail the opportunity for proper use.

5.2 Options for addressing problems with cabinet heaters

Given the uncertainties and data limitations in the quantified cost benefit analysis it is difficult to categorically declare cabinet heaters to be net benefit or net cost to New Zealand, but there is evidence to suggest substantial hidden costs, particularly in the health area rather than in safety risk and cost of operation that tend to receive more media attention. Reducing these costs without incurring greater costs and risks in the process would be beneficial for New Zealand.

A number of possible options for addressing problems have come to light in the course of this review. An overarching requirement in considering these options is to achieve a net benefit, and retain access to heating for those who currently rely on cabinet heaters for this purpose; i.e. avoid curtailing proper use of heaters or ensure feasible substitutes for those whose use may be affected.

5.2.1 Improved information dissemination on safe and healthy use

Both in consultation and from literature examined there is a widespread view that mis-information surrounds the use of cabinet heaters. Surveys suggest that LPG cabinet heater users have a general understanding of the requirements for safe use, but a substantial number of them lack some important detail (like the advisability of opening ventilation to the outside, rather than just to other parts of the house). The view still persists, even reportedly among some budget advisers, that LPG cabinet heaters are a “cheap” form of heating, even though there is relative running cost information to the contrary readily available from at least three sources – the websites of EECA, Ministry for the Environment and Consumer NZ.

Finding more effective ways of reinforcing safety measures, and of spreading information on relative running costs could be a low cost way of reducing the likelihood of avoidable incidents brought about by ill-informed behaviour. There could be information failure, or rather information dissemination failure, that would warrant some intervention or encouragement of further efforts in this area.

This is not a new finding. The LPGA, in conjunction with ERMA and Energy Safety, have in recent years run campaigns in the winter seasons distributing leaflets and swing-tags with such information to be given to customers when refilling their LPG bottles. Energy Safety sought a voluntary agreement with importers and distributors of such cabinets on providing such information.

A number of those consulted remarked on the absence of safety information affixed to the cabinet heaters in positions where it could be seen, both at point of sale and when in use, and commented on information distributed with the heater's operating instructions as the first thing discarded after the packaging.[31] This raises the question of whether improved visibility labelling of cabinet heaters, incorporating colour and punchy safety messages, could be further investigated. Such a label itself should not be costly to design, produce and distribute; it could be attached to the appliances at either the retailer or the manufacturer, depending on where it is most effective to do so. Such labelling does not fit within current labelling schemes such as Mandatory Energy Performance Standards labelling so a separate mechanism, regulation or voluntary code would be needed to bring such labelling into effect.

While labelling may be effective in disseminating safety messages with new heaters, reaching the stock of existing heaters is more challenging. The winter information campaigns of LPGA and its associates may provide a base to build on in getting information to bottle fillers to affix to their appliances. It has also been suggested that people are more receptive to changing behaviour on becoming parents than at other times, so that information and advice on use of heaters could be distributed through existing systems for supporting the new born (such as Plunket nurse visits), reducing exposure of that part of the population that is particularly susceptible to the adverse health effects of unflued LPG heaters. Distribution of safety messages with asthma medication could also be considered. While it might be argued that education and information has been tried and found wanting, this review has not found evidence of systematic examination of the effectiveness of current information measures, or that all options for improving information dissemination have been exhausted.

5.2.2 Develop standards applying to cabinet heaters

Cabinet heaters do not have a New Zealand specific standard at present, but are required to meet the requirements of various overseas standards, particularly a European standard specific to cabinet heaters. Standards for energy efficiency or safety characteristics could be developed (e.g. a CO monitor linked to cut-off when

[31] Judging by cabinet heater models seen for sale in a South Dunedin branch of the Warehouse on 10 April 2010, such safety information is included with operating instructions on a panel in black and white print fixed inside the cabinet where it may be partially obscured by the gas cylinder.

thresholds exceeded[32]), but no agency currently has responsibility for the whole cabinet heater appliance or in developing standards for this purpose.

Reliance on overseas standards governing design of cabinet heaters is not unique to LPG cabinet heaters in New Zealand, and development of a New Zealand-specific standard could be quite costly for the level of risk presented by LPG cabinet heaters. Some consultees suggested refinements to design, such as additions of CO monitors or design of guards to reduce likelihood of flammable fabrics touching the flame, but as these heaters are manufactured overseas to standards set in larger markets than the 45,000 or so heaters sold annually in New Zealand, it is questionable how effective local standards would be. New Zealand already has a degree of implicit standard setting over the design characteristics for valves and connection points, and has found some options limited by the manufacture of key components overseas.

5.2.3 Withdraw use of heaters from institutional settings

Withdrawal of uses of cabinet heaters from institutional settings such as schools, hospitals, rest homes etc, has been suggested, a move which may reflect experience in Victoria where removal of unflued gas heaters from institutions has already been mandated. Exposing those attending these institutions to the adverse health effects of unflued heaters is a genuine externality, as attendees generally have no control over the choice of heating. It could be achieved through guidance issued to public sector institutions, or by regulation extended to private ones.

Such institutions should be large enough to have more healthy and energy efficient heating options available and feasible, so beyond the administrative costs of setting the process in motion, such a move would not be costly and may provide savings in institutional energy use. However, this review has found no evidence that the use of cabinet heaters in such settings is widespread in New Zealand.

5.2.4 Increase subsidy assistance for cleaner heat to low income households

Use of cabinet heaters is commonly associated with those on low incomes who find it hard to overcome the hurdle of up-front installation costs of cleaner and more efficient heating such as heat pumps, wood burners or flued gas appliances. Increasing the subsidy assistance for improved heating to low income households might be one way to increase the replacement of cabinet heaters with more efficient and cleaner heating devices.

Statistics suggest a disproportionately small share of cabinet heaters in households with the lowest incomes, so such increased subsidy will not affect all, or even a majority, of those facing the hidden costs of cabinet heater use. To date 60% of the heating subsidies available under Warm Up New Zealand have been taken up by those with community services cards. There may be some households facing

[32] The low reported number of CO poisoning cases associated with cabinet heaters in New Zealand suggests there are few incidents where such CO monitors would be beneficial.

particular hardships who could benefit from additional assistance, but such schemes would need careful design to achieve the desired improvement in heating delivery, and avoid simply subsidising a housing improvement for householders that becomes capitalised into the value of the property.

There may be a case for increasing assistance to low income households to improve the adequacy of their heating. This will create particular costs for administration and implementation but may only have limited impact on replacing LPG cabinets heaters, and hence limited benefit in reducing the hidden costs of cabinet heaters.

5.2.5 Inspection and warrant of fitness regime for cabinet heaters

One option to alleviate concerns about the frequency and adequacy of current maintenance of cabinet heaters, would be to institute a system of inspection of heaters in use, with a warrant of fitness issued on a periodic basis. This would bring the heater appliance within the ambit of regulatory control, in a similar manner to the LPG bottles that are required to be tested every 10 years.

While there has been concern about the recent increase in incidents concerning cabinet heaters, according to Energy Safety most of these incidents appear to owe more to user behaviour than to appliance faults, so it is questionable how much benefit an inspection regime would provide. There would certainly be costs in running such an inspection regime, whether through government agency inspectorates or under contract to private testing organisations. Such a scheme is likely to be more costly to enforce than is warranted by the low number of cabinet heater incidents that can be attributed to poor maintenance.

5.2.6 Banning the sale or use of cabinet heaters

Banning the sale or use of cabinet heaters were the most commonly mentioned options in consultation undertaken in this review. These would have a direct effect on reducing the adverse effects from using these cabinet heaters, but would also have consequences for the availability of heat for those who currently opt to use them.

Banning the sale of new cabinet heaters would be the simplest approach and could be achieved by withdrawing approval for sale of these appliances in the compliance process. However, this could result in a long phase down period when the average age of heaters in the nationwide stock of heaters would be increasing. Prolonged use of older and possibly less well maintained heaters as spares for older models become scarcer could be counter-productive in increasing the risk of fire or CO incidents associated with these heaters. As it appears from current market data that about 10% of the stock of cabinet heaters is renewed each year, the stock would take 10 years to be phased out, but longer if appliances are kept in use longer.

Banning the use of cabinet heaters would be more costly and contentious, as it tramples on perceived property rights to choose and use cabinet heaters. It is also likely to be costly to enforce as use of these heaters is not directly monitored, so additional resources would be required to check on compliance and oversee the phased withdrawal of these heaters from circulation. As indicated earlier, a rapid withdrawal of the energy outputs of cabinet heaters from the national energy mix could precipitate impacts on the electricity supply system, bringing forward costs of new generation, transmission and distribution facilities. A phased withdrawal of use would be more readily accommodated, perhaps targeting first those households most at need of alternative heating, i.e. those most reliant on cabinet heating.

It might also be necessary to bring in extra subsidies for heating replacement, contingent on old cabinet heaters being brought in for disposal. Such subsidies used to date have generally focused on improving the housing stock through fixed installations, rather than rewarding individuals for purchases that, once made, they could on-sell and be no better off than before, so such a scheme would need careful design to ensure it delivers improvement in heating to those who need it.

Although banning the use of cabinet heaters would reduce ill health and safety risks to some in the community, it also denies the use of such heaters to those less susceptible to the health effects and results in some loss of functionality among available domestic heating choices. This particularly relates to the preference for pre-payment of energy for budgetary purposes, and the independence of interruptible reticulated energy supplies. While interruption of energy supplies, due to bad weather or budgetary mismanagement, does not happen very often, when it does in the absence of cabinet heaters it may result in increased risks from improper use of appliances not designed for use indoors, such as barbecues and patio heaters.

5.3 Summing up on options

A full comparative analysis of all the options for dealing with cabinet heaters is beyond the scope of the current review. This section has considered a number of options that have been raised in the course of the review, but a further detailed investigation would be required to take these options further.

None of the options considered has international trade implications, provided they are implemented in a way that does not discriminate between local and imported products. Most options are unlikely to significantly affect competition and investment in markets for space heating, other than bans and subsidies for alternative heating.

The principal benefits, costs and risks of the different options is summarised in the table below.

The options that would minimise impacts on innovation, investment, competition, individual responsibility and property rights are those at the top of the table. In light of the findings of this review, further investigation would be warranted into these less intrusive options, in particular the effectiveness of information dissemination on safe use of cabinet heaters in reaching users and changing behaviour, and in targeting those susceptible to the health risks identified in this review.

Table 18 Summary of options

Option	Benefits	Costs	Risks
Improving information dissemination on health & safety - on heaters	Raising visibility of messages on heaters; (optimal design and effectiveness to be determined) - better care by users leading to lower health and safety hazards	Costs of research and design of labels; costs of compliance for retailers/importers; low enforcement costs	Messages prove to be ineffective; not targeted at population at risk; does not reach existing stock of heaters
Improving information dissemination on health & safety - new channels, e.g. on medications, through Plunket	Raising awareness of health and safety messages leading to reduced exposure for those at risk	Costs of research and design of labels; costs of compliance for retailers/importers and others in distribution; low enforcement costs	Messages may prove to be ineffective but are targeted at populations at risk
Development of NZ standards for cabinet heaters	Reducing incidents caused by non-standard appliance components	Cost of research and setting of standard; compliance cost for retailers/importers; administrative cost for standard oversight	NZ may have little influence on overseas made components
Attachment of CO monitors that warn of excessive CO emission	Reduction in incidence of CO related harm (already a low rate of incidents)	Cost of attaching monitors to cabinets	Difficult to reach all existing heaters; costs may exceed benefits given low CO incidents
Withdrawal of use of heaters in institutional settings	Reducing health and safety effects of cabinet heaters in schools and hospitals (not identified as a significant problem in NZ)	Costs of replacement heating appliances; promotional material; monitoring	Costs may outweigh any appreciable benefit
Increase subsidy assistance to low income households for changing to low risk heaters	Reducing health and safety effects of cabinet heaters in low income households	Cost of subsidising replacement heating; costs of administering the scheme	Cabinet heater users outside the low income category not assisted; low uptake if low income households cannot surpass the hurdle of capital cost
Warrant of fitness regime for cabinet heaters	Reducing health and safety effects arising from poorly maintained cabinet heaters (not identified to be a major cause of incidents)	Administrative cost of implementing scheme including enforcement; compliance costs for heater users	Risk of incomplete coverage due to incomplete knowledge of heater distribution; risks of costs outweighing small benefit
Banning the sale of cabinet heaters	Gradual removal of cabinet heaters from residential settings, leading to improvement in health and safety	Cost of replacement heating appliances; administrative costs of enforcement	Risk of deteriorating heater stock without renewal; or of people using alternative appliances less suited for indoor use
Banning the use of cabinet heaters	More rapid removal of cabinet heaters from residential settings, leading to faster improvement in health and safety	Cost of replacement heating appliances; administrative costs of enforcement; one-off costs on electricity infrastructure upgrades	Risk of functional loss in some situations (e.g. temporary electricity outages); or of a gap in the market filled by other appliances (patio heaters used indoors)

Source: NZIER

6. Conclusions

This review has examined the use in New Zealand of cabinet heaters, which are portable heaters incorporating a 9kg LPG bottle designed to be used indoors. Their benefit to their users is in providing controllable heat that can rapidly warm up a space, which is portable between rooms and properties and which is independent of interruptible reticulated energy supplies, and also allows pre-payment of energy which some people prefer for budgetary purposes. As they pose some risk of fire, leakage and carbon monoxide poisoning, and vent their exhaust gases into the indoor air around them which, without adequate ventilation, can degrade indoor air quality with a variety of adverse consequences to health, concerns have arisen about their continuing suitability for use, particularly in residential settings.

Statistics on cabinet heaters are fragmented but it is likely that there are around 450,000 to 500,000 LPG cabinet heaters in New Zealand and they are found in no more than around 21% of households (310,000), with the balance in use in non-residential settings like restaurants and workshops. Recently they have provided around 24% of residential space heating energy and 8% of total residential energy, but their use has been declining over the past 3-4 years in face of increases in LPG prices and greater market penetration of other heating systems such as heat pumps. They have relatively low purchase prices but relatively high running costs per unit of energy, and are now one of the most expensive forms of energy for large heating loads, although less expensive for light heating loads or supplementary heating use.

This review has interviewed a wide variety of people and organisations with an interest in LPG cabinet heaters, many of whom were concerned with the hidden non-financial costs of health and safety risk and the apparent inconsistency with other government moves to increase the energy efficiency and insulation of New Zealand's housing stock. Many suggested banning such heaters in New Zealand, but others regard them as having a role and only requiring improvements in design and information about their proper use.

This review has estimated the costs and benefits of cabinet heaters against the alternative of heating load being provided by portable electric plug-in heaters. The results suggest that in aggregate the costs of cabinet heaters exceed their benefits, principally because of large health costs concentrated on a susceptible subset of the population and with adverse impacts borne largely by the users themselves, rather than as an externality on third parties. As there appear to be mistaken beliefs about the characteristics of cabinet heaters, there may be a market failure in the dissemination of information about their proper use.

As health costs are borne principally by a susceptible minority of the population an appropriate response is to target reducing exposure of the at-risk part of the population. Investigating ways of improving dissemination of information about safe and proper use would address concerns around use of LPG cabinet heaters but cannot eliminate risks entirely.

Appendix A References

Abelson, P. (2003). The value of life and health for public policy. *The Economic Record*, 79 (special issue), S2-S13.

Beacon Pathway Ltd., National Value Case for Sustainable Housing Innovations: Making the case for the national benefit to be gained by transforming the New Zealand housing stock – both new and existing - to improve sustainability, Beacon Pathway Limited October 2007.
www.beaconpathway.co.nz/images/uploads/National_Value_Case_booklet_final30Nov07.pdf.

BRANZ (2006) Energy End Use in New Zealand Households – Report on Year 10 Analysis for the Household Energy End-use Project (HEEP), Study Report 155, Building Research Association of New Zealand, Wellington

Consumers' Institute (2009) Consumer #490, April, www.consumer.org.nz

Concept Consulting Group Limited (2009). *Cost: benefit analysis for increasing the direct use of gas in New Zealand* – A report prepared for Gas Industry Co – Duog Concept Report (Final).

Courtney C (2009) "Heating Heartache"; *North & South*, June

Denison et al (2000) Health Effects of Five Common Air Contaminants and Recommended Protective Ranges – Air Quality Technical Report No.12. Report prepared for the Ministry for the Environment. Ministry for the Environment: Wellington. Retrieved from http://www.mfe.govt.nz/publications/air/5-common-air-oct00.pdf.
Accessed 3 March 2009.

Department of Environment and Heritage (2004) Un-flued gas appliances and air quality in Australian homes, 2004 .
http://www.environment.gov.au/atmosphere/airquality/publications/report9/index.html

EECA 2009, Product Profile; Gas Space and Decorative Heaters.

enHealth (2007). *The health effect of unflued gas heater use in Australia*. Canberra. Department of Health and Aging. – website
http://www.health.gov.au/internet/main/publishing.nsf/Content/F764F6AF98AA0A6CCA2573AF007F7D0D/$File/unlfued%20gas%20heater%20use.pdf.

European Committee for Standardization (CEN) EN 449: 2002 Specification for dedicated liquefied petroleum gas appliances – Domestic flueless space heaters (including diffusive catalytic combustion heaters).

European Federation of Allergies and Airways Diseases (2004) Towards Healthy Air in Dwellings in Europe. Patients Associations: Belgium. Retrieved from http://www.euro.who.int/Housing/20090312_1.
Accessed 22 March 2009.

Fisher, G. et al (2007) Health Pollution and Air Pollution in New Zealand – Main Report. Prepared for the Health Research Council of New Zealand, the Ministry for the Environment and the Ministry of Transport: New Zealand. Retrieved from http://www.hapinz.org.nz/.
Accessed 3 March 2009.

Fryer, K., Palmer, S. and Kalafatelis, E. (2006). *Final Report: A consumer survey of users of LPG cabinet heaters*. Research New Zealand Report prepared for Ministry of Consumer Affairs.

Gillespie-Bennett G et al (2008) Sources of nitrogen dioxide (NO_2) in New Zealand homes: findings from a community randomized controlled trial of heater substitutions. Indoor **18** (6): 521-528.

Guria, J., Jones, W., Jones-Lee, M. W., Keall, M., Leung, J. and Loomes, G. (2003). *The New Zealand Values of Statistical Life and of Prevention of Injuries*. Wellington, Land Transport Safety Authority.

Hansel, N. N., Breysse, P.N., McCormack, M. C., Matsui, E. C., Curtin-Brosnan, J., Williams, D. L., Moore, J. L., Cuhran, J. L. and Diette, G. B. (2008). A Longitudinal Study of Indoor Nitrogen Dioxide Levels and Respiratory Symptoms in Inner-City Children with Asthma. *Environmental Health Perspectives*, 116(10). 1428-1432

He Kainga Oranga/the Housing and Health Research Programme et al (2005) Housing, Heating and Health Study: Heater Analysis. University of Otago, Wellington School of Medicine and Health Sciences: Wellington.

Holt, S. and Beasley, R. (2001). The Burden of Asthma in New Zealand. Asthma and Respiratory Foundation of New Zealand, (Inc.) Wellington.

Howden-Chapman, P. et al (2009) Warm Homes: Drivers of the demand for heating in the residential sector in New Zealand. Energy Policy, doi: 10/1016/j.enpol.2008.12.023.

Howden-Chapman, P. et al (2007) Effect of insulating existing houses on health inequality: cluster ramdomised study in the community. BMJ, doi:10.1136/bmj.39070.573032.80.

Howden-Chapman, P., Pierse, N., Nicholls, S., Gillespie-Bennett, J., Viggers, H., Cunningham, M, Phipps, R., Boulic, M., Fjällström, P., Free, S., Chapman, R., Lloyd, B., Wickens, K., Shields, D., Baker, M., Cunningham, C., Woodward, A., Bullen, C. Crane, J. (Howden-Chapman, P. et al 2008). Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. BMJ 2008;337:a1411 doi:10.1136/bmj/a1411.

Howden-Chapman, P. et al (2006) Housing, Heating and Health Study: 2005/2006 Report Two – home heating systems: preferences and trade-offs. Report to Funders. He Kainga Oranga/Housing and Health Research Programme. Otago School of Medicine: Wellington.

Howden-Chapman, P. et al (1999) Housing and Health in Older People: Ageing in place. Social Policy Journal of New Zealand, Issue 13. Retrieved from http://www.msd.govt.nz/about-msd-and-our-work/publications-resources/journals-and-magazines/social-policy-journal/spj13/housing-and-health-in-older-people.html. Accessed 22 March 2009.

Howden-Chapman, P et al (nd) Retrofitting Homes with Insulation to Reduce Health Inequalities: Aims and methods of a clustered, randomized community-based trial. *In press.*

Jones-Lee, M. W. and Loomes, G. (1995). Discounting and Safety. Oxford Economic Papers, 47, 501-512.

Kingham, S., Durand, M., Harrison, J., Cavanagh, J., Epton, M., Temporal variations in particulate exposure to wood smoke in a residential school environment, Atmospheric Environment, Received 15 November 2006; received in revised form 23 January 2008; accepted 28 January 2008.

Kingham, S. (n.d.) *Sci-5 - Gas Heaters in Homes*. University of Canterbury: Christchurch. Retrieved from http://www.outreach.canterbury.ac.nz/podcasts/gas_heaters.shtml. Accessed 25 March 2009.

Levy, J. I., Welker-Hood, L. K., Dougherty, J. E., Dodson, R. E., Steinbach, S and Hynes, H. P. (2004). Lung function, asthma symptoms, and quality of life for children in public housing in Boston: a case-series analysis. *Environmental Health: A Global Access Science Source* 2004, **3**:13 doi:10.1186/1476-069X-3-13. http://www.ehjournal.net/content/3/1/13.

Lindhjem, H., Navrud, S. and Braathen, N. A. (2010). Valuing lives saved from environmental, transport and health policies: A meta analysis of stated preference studies. Paris. OECD.

Mason, H., Jones-Lee, M. and Donaldson, C. (2009). Modelling the monetary value of a QALY: a new approach based on UK data. *Health Economics*, 18(8), 933-950.

Mathers, C., Vos, T. and Stevenson, C. (1999). *The Burden of Disease and Injury in Australia*. Australian Institute of Health and Welfare. Canberra, AIHW cat. no. PHE 17.

Miller, T. R. and Guria, J. (1991). The Value of Statistical Life in New Zealand: Market Research on Road Safety. Wellington, Ministry of Transport.

Millichamp, P & Wilton, E. (2002) *Reducing Emissions from Domestic Home Heating – Air Quality Technical Report No.26*. Report prepared for the Ministry for the Environment. Ministry for the Environment: Wellington. Retrieved from http://www.mfe.govt.nz/publications/air/reducing-emissions-domestic-fires-may02.pdf. Accessed 3 March 2009.

Ministry of Transport (2009). *The Social Cost of Road Crashes and Injuries: June 2009 update*. Wellington. Ministry of Transport.

Ministry for the Environment (2005a) Warm Homes Technical Report: Detailed Study of Heating Options in New Zealand – Phase 1 Report; Wellington.

Ministry for the Environment (2005b) Warm Homes Technical Report: Social Drivers – Phase 1 Interim Report; Wellington.

Ministry for the Environment (n.d.b) *Heating Appliance PM_{10} Emissions*. Retrieved from:
http://www.mfe.govt.nz/publications/energy/warm-homes-heating-options-phase1-nov05/html/images/heating-appliance-pm10-emissions.html.
Accessed on 3 March 2008.

Ministry for the Environment (n.d.c) *Appliance Operating Costs – including open fires*. Ministry for the Environment: Wellington. Retrieved from http://www.mfe.govt.nz/publications/energy/warm-homes-heating-options-phase1-nov05/html/images/appliance-operating-costs-including-open-fires.html. Accessed 21 March 2009.

Ministry of Health (0205) unflued gas heater pamphlet titled Unflued Gas Heaters & Your Health *http://www.moh.govt.nz/moh.nsf/indexmh/unflued-gas-heaters-may05*.

Nitschke M., Pilotto L. S., Attewell, R. G., Smith, B. J., Pisaniello, D., Martin, J., Ruffin, R. E. and Hiller, J. E. (2006). A cohort study of indoor nitrogen dioxide and house dust mite exposure in asthmatic children. *Journal of Occupational and Environmental Medicine*, 48, 462–469.

Orion (2009) “Impact of Environment Canterbury’s Clean Heat project on Christchurch electricity usage”; Report by Orion, Meridian & Environment Canterbury

Page, I. (2009). Cost of Repair to Fire Damaged Buildings. Wellington. BRANZ. New Zealand Fire Service Commission Report Number 91.

PCE (2006) *Healthy, wealthy, and wise: A health impact assessment of Future currents: Electricity scenarios for New Zealand 2005–2050*, Parliamentary Commissioner for the Environment, November 2006 ISBN 1-877274-32-1.

Available on the Commissioner's website: www.pce.parliament.nz/work_programme/reports_by_subject/all_reports/energy__and__climate/healthy_wealthy.

Pilotto, L. S., Nitschke, M., Smith, B. J., Pisaniello, D., Ruffin, R. E., McElroy, H. J., Martin, J. and Hiller, J. E. (2003). Randomized controlled trial of unflued gas heater replacement on respiratory health of asthmatic school children. *International Journal of Epidemiology*, 33, 208-214.

Pilotto et. al. 2004 Randomized controlled trial of unflued gas heater replacement on respiratory health of asthmatic schoolchildren. http://ije.oxfordjournals.org/cgi/content/abstract/33/1/208

Ponsonby, A. L., Dwyer, T., Couper, D., Cochrance, J. and Carmichael, A. (2001). A prospective study of he association between home gas appliance use during infancy and subsequent dust mite sensitization and lung function in childhood.

Sanderson, K., Goodchild, M., Nana, G., & Slack, A. (2007). *The Value of Statistical Life for Fire Regulatory Impact Statements*. Wellington. BERL. New Zealand Fire Service Commission Report Number 79.

Shima, M. and Adachi, M. (2000). Effect of outdoor and indoor nitrogen dioxide on respiratory symptoms in schoolchildren. *International Journal of Epidemiology*, 29, 862-870.

Smith, B., Nitschke M., Pilotto L., Ruffin, R., Pisaniello, D. and Wilson, K. (2000). Health effects of daily indoor nitrogen dioxide exposure in people with asthma. *European Respiratory Journal*, 16, 879-885.

Southey C & Strokes M (2009) "Recommendation to the Associate Minister on the Direct Use of Gas"; Report to the Gas Industry Company Ltd

TenWolde A & Pilon C (2007) "The effect of indoor humidity on water vapour release in homes" American Society of Heating Refrigerating and Air-Conditioning Engineers

Tolley, G., Kenkel, D. and Fabian, R. (1994). State of the art health values in Tolley, G., Kenkel, D. and Fabian, R. (eds). *Valuing Health for Public Policy, an Economic Approach*. Chicago. University of Chicago Press. 323-44.

University of Otago (2009) "Retrofit interventions to enable healthy living conditions in existing NZ houses"; Energy Studies Research Report www.energywise.govt.nz/sites/ml/filters/retrofit-intervention-report-July-2009

Wakelin, W S (Bill) *Report of Inquiry into the Use of LPG Cylinders in Indoor Situations* (INQ03014), W S (Bill) Wakelin, 9 May 2004, ISBN 0-475-21524-X. Available at: www.ermanz.govt.nz/resources/publications/pdfs/INQ03014.pdf.

Wilton E & Baines M (2009) "Product Profile – Residential Gas Heaters in New Zealand", Environet Ltd

World Health Organization (2009a) *Healthy Indoor Environments Protect Children's Health*. Retrieved from http://www.euro.who.int/eprise/main/WHO/MediaCentre/PR/2009/20090126_1?language Accessed 22 March 2009.

World Health Organization (2009b) *The World Health Organization Approach to Housing and Health.* Retrieved from http://www.euro.who.int/Housing/20080319_10. Accessed 22 March 2009.

World Health Organization (2004) *Review of Evidence on Housing and Health: Background Document*. Prepared for the Fourth Ministerial Conference on Environment and Health in Budapest, Hungary. World Health Organization: Europe. Retrieved from http://www.euro.who.int/document/HOH/ebackdoc01.pdf.

World Health Organization (WHO 2005) Air Quality Guidelines, Global Update (http://www.euro.who.int/Document/E90038.pdf)

Appendix B The Value of Statistical Life

Losses of life and life quality are the major components of social costs of fatalities and injuries. The modern approach to placing an economic value on loss of life and life quality (which is unavoidable if health and safety are to be weighed up against other demands for society's resources) is not to attempt to place a value on any known individual's life. Rather, it infers from observed behaviour or stated preferences across the population at large the average willingness to pay of individuals to reduce the risk of fatal injury, as a guide to society's willingness to pay to reduce the risk of fatality among its members.

Willingness to pay for small changes in the risk of fatality are scaled up to indicate the average societal willingness to pay to avoid one fatality. The loss of life is measured by the Value of Statistical Life (VOSL)[33]. The loss of life quality due to serious or minor injuries is commonly estimated as a proportion of the VOSL.

Ministry of Transport (MOT) estimates the social costs per injury every year. They categorise injuries as fatal, serious and minor. Serious injuries are mostly hospitalised injuries. Minor injuries are simply cuts and bruises with small long term effects in some cases (e.g. the lasting effects of whiplash). It is not clear if the long term effects of minor injuries in the case of unflued LPG heaters would be similar. We use the Ministry of Transport (2009) costs to start with and then vary the loss of life quality component for minor injuries.

The value to society of loss of a statistical life is estimated as $3.5 million by Ministry of Transport. We use the same value for fatalities caused by LPG cabinet heater accidents, on the grounds that a life and society's willingness to pay for safety remains the same irrespective of the cause of the accident. The data indicate fatal injury occurred to either elderly people or children. The two studies undertaken in New Zealand on value of statistical life (Miller and Guria 1991, Guria et al 2003) did not show any relationship with age, though one study (Miller and Guria 1991) showed a slightly lower average value of those above 60 years of age.

A recent OECD report (Lindhjem et al 2010) that reviews updated work internationally since then supports the view that VOSL does not vary by age. Their argument is that while elderly people have fewer years to live, each year is still valuable to them and, moreover, they often have the ability to pay more. As a result, that report indicates that the VOSL for elderly people can even be higher than the average VOSL. We apply the same VOSL for all and use the MOT estimate as the best available basis for placing economic value on the health and safety impacts of cabinet heaters.

[33] Value of Statistical Life (VOSL) is the value to society of avoiding a premature death. It is estimated in New Zealand as the amount of money New Zealand residents are willing to pay to reduce the risk of death so that one premature death is avoided.

Another study by BERL (Sanderson et al 2007) estimated the relativity between value to society of saving a road accident death and a fire accident death, and found the value of saving a fire accident death is about 66% of the value of saving a road death. However, we have not used this to estimate the loss to society of fire deaths from cabinet heaters because we believe the methodology used would not provide a robust estimate.

The BERL study used a questionnaire survey to ask respondents how they would like government to direct its efforts if it had resources to save 20 accidental deaths. The survey responses suggested respondents would like to save 12.4 road deaths and 7.6 fire deaths. Based on this the BERL study report suggests

> *"The average relativity between the population's stated preference for saving lives from fire accidents as measured by this survey is 61.3% of the value of saving lives from road accidents" (Sanderson et al 2007, p 40).*

We cannot find any justification for this in the BERL report or the international literature on safety economics. About 400 lives are lost in road accidents every year, whereas only about 20 lives are lost in fire accidents. If respondents were given this information, perhaps their responses would have been different. As it stands, if the respondents preferred to save 7.6 lives out of 20 lives during a year and 12.4 lives out of 400 lives which would otherwise have been lost, that would indicate they put higher value of avoiding fire accident death (for which risk to the population is lower) than a road accident death (where the population risk is higher) – not the other way as suggested in the report.

In a recent report Mason et al (2009) notes that in the UK a willingness to pay-based value of safety is used by all government agencies.

> "Thus, in the UK, for example, the Department for Transport (DfT), the Rail Industry, the Department for the Environment, Food and Rural Affairs (DEFRA) and other government agencies all employ WTP-based values of safety in their cost-benefit analyses." (Mason et al 2009, p 934).

Mason et al (2009) also state that all these agencies in the UK use the same value except for prevention of cancer death, in which case the Health and Safety executive recommends a value twice as high. Taking into account these findings, we believe it is appropriate to use the same VOSL as in the transport sector in our estimates.

Appendix C People consulted in this review

Asthma New Zealand.	Jane Patterson
Auckland DHB	Dr Denise Barnfather
Beacon Pathway Ltd.	Verney Ryan
BRANZ.	Andrew Pollard
Canterbury DHB	Lew Graham, Anne Currie
Community Energy Action	Bede Martin
Consumer New Zealand.	Bill Whitley
Cylinder Test Laboratory Association	Chris O'Connor
Energy Efficiency and Conservation Authority (EECA).	Ed Winter
Energy Options Charitable Company Limited	Jo Hunt
Environment Canterbury	Linda Kirk
Environmental Risk Management Authority NZ (ERMA).	Bryan Watts
Gas Lab	David Howell
Local Government New Zealand.	Irene Clark
LPG Association of New Zealand.	Peter Gilbert
Ministry for the Environment (MfE).	Daniel Moore
Ministry for the Environment (MfE).	Louise Wickham
Ministry of Economic Development	James Ryan
Ministry of Health (MoH).	Frances Graham
Ministry of Health (MoH).	Paul Prendergast
Ministry of Social Development (MSD).	Jane Morgan
Ministry of Social Development (MSD).	Luke Smith
New Zealand Council of Elders.	Pat Cunniffe
New Zealand Fire Service.	Alan Merry
New Zealand Fire Service.	Neil Challands
Royal New Zealand Plunket Society.	Sue Campbell
Sustainable Energy Forum	Molly Melhuish
Tenants Protection Association	Helen Gaytonyi
The Warehouse Group Limited.	Richard van Orton
University of Otago (Wellington School of Medicine).	Neville Pierse
Sustainability Trust	Phil Squire
Department of Building & Housing (DBH).	Nick Locke
Department of Building & Housing (DBH).	Nick Saunders
Department of Labour (DoL).	Kim Comben
Gas Association of New Zealand.	Stephen Parker
Gas Equipment Suppliers group.	C/- Gas Association of NZ
Housing New Zealand.	Peter Hannam
Ministry of Economic Development Energy Safety	Keith Rodgers
Ministry of Economic Development	Ross Milner
Ministry of Economic Development	David Buckrell
<u>Those who declined to participate</u>	
Domestic Energy Users' Network.	Bruce Twidle
Home Heating Association.	Evan Harris
Ministry of Civil Defence and Emergency Management.	Adrian Prowse
Ministry of Pacific Island Affairs.	Diane Anorpong
National Council of Women.	Lynda Sutherland
Parliamentary Commissioner for the Environment.	Simon Watts