

**Preliminary Report:
Health Impact Assessment
on the proposed
Air Quality Plan Change**



Prepared by: Ana Apatu and Maree Rohleder
Hawke's Bay District Health Board

In partnership with Hawke's Bay Regional Council

With assistance from Quigley and Watts Ltd
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Foreword: Whanau Ora - The concept of holistic wellbeing

The relationship between air quality, heat and health/wellbeing may be foreign to some people but understanding how broader factors might influence health is essential for understanding why a health impact assessment might be undertaken. Further, Maori models of wellbeing are important within a New Zealand context, particularly in Hawke's Bay. Such a model is Te Pae Mahutonga, a Maori conceptual framework which can be used as a guide in developing strategies.

Te Pae Mahutonga is the constellation of stars popularly referred to as the Southern Cross. Each pointer describes an element of wellbeing:

Mauriora access to te ao Maori, which can lead to a secure cultural identity.

Waiora acknowledges environmental protection. It acknowledges the link between people and the natural environment. It encourages people to take care of their communities and the natural environment.

Toiora - promotes health lifestyles

Whaiora- participation in the wider community

Nga Manukura- supporting Maori leadership

Te Mana Whakahaere autonomy, self governance.

(Adapted from Professor Mason Durie's Te Pae Mahutonga Model)

Community Development

The foundation of good decision-making in environmental health issues such as air quality lies in the meaningful involvement of affected people in the community and giving them opportunities to participate in planning processes that may affect them.

Community development is recognised as a key mechanism of achieving population health targets. Development of Maori communities requires recognition of the needs, concerns, interests and distinctive situations of Maori. This requires government, non-government organizations and hapu and Iwi to work together in partnership.

(ESR –Waste Management, Models of Maori Community Development 08)

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Executive Summary

Air quality in Hawke's Bay complies most of the time, but monitoring by the Hawke's Bay Regional Council shows that high PM₁₀ levels (dust and smoke) occur over the Hastings and Napier urban areas on cold, clear winter nights and that the main cause is domestic home heating, i.e. wood burners and open fires.

By September 2013 the amount of PM₁₀ in the air cannot exceed a 24 hour average of more than 50 µg/m³ (microgram per cubic meter) more than once per year as required by Ministry for the Environment National Environmental Standards for Air Quality (NESAQ).

PM₁₀ levels over Napier and Hastings urban centres on cold, clear winter nights currently exceed this NESAQ.

The Hawke's Bay Regional Council is currently developing a local approach to comply with the NESAQ. In December 2008, a plan change was proposed to improve air quality in Hawke's Bay - particularly within the Napier and Hastings airsheds. Key features of the proposed plan change are rules restricting outdoor burning and small-scale solid fuel burners as it has been identified that these are the main cause of the exceedances in air quality. These restrictions include:

- from 2011, all open fires and burners that do not comply with the NESAQ installed before 31 December 1995 will be prohibited from use;
- from 2012, all burners that do not comply with the NESAQ installed before 31 August 2005 will be prohibited from use;
- from 2013, all burners that do not comply with the NESAQ will be prohibited from use;
- all new and replacement solid fuel burners in the Hastings Airshed must meet an emission rate of 0.7 grams of PM₁₀ for each kilogram of wood burned;¹

As a result of the Proposed Air Quality Plan Change (Plan Change) the Hawke's Bay Regional Council has also developed a Healthy Homes and Clean Heat Initiative. This

initiative provides financial assistance for households towards insulation and clean heat and includes communications and marketing and public education. The initiative is expected to help ease the transition for households towards home heating solutions which do not lead to breaches of the NESAQ for PM₁₀.

The Hawke's Bay Regional Council (HBRC) was invited to engage with the Hawke's Bay District Health Board (HBDHB) to conduct a health impact assessment (HIA) on the Plan Change.

Public health and wellbeing are not solely determined by the health sector, as many people assume. The health sector spends the majority of its budget on treating unwell people but only a very small amount (approximately 2 percent in direct funding channels) on attempts to prevent illness. Other public sector areas outstrip the health sector in their potential to affect, protect, and promote population health; their actions can have a significant impact on environmental and social health.

The four stages of a typical health impact assessment (HIA) have been undertaken, drawing together evidence from the social science literature, community representatives, community organisations and the Hawke's Bay Regional Council.

It was decided to concentrate on the replacement/removal of heating sources, including both the ongoing costs/impacts and the one off costs/impacts on the low income population group. This decision was taken because it was the component most able to be influenced at this stage in the Plan Change, and the implementation of this component covers important issues for Council and the community such as financial assistance which could be part of the clean heat initiative. The health impact assessment has identified two major ways in which the NESAQ, Plan Change and the clean heat initiatives might impact on health and wellbeing:

1. Intended effects on outdoor ambient air quality (PM₁₀) and subsequent direct and indirect impacts on health and wellbeing;

2. Unintended effects on indoor air quality and temperature and subsequent direct and indirect impacts on health and wellbeing.

Findings

Context

Sixty seven percent of privately owned homes in Hawke's Bay were built before insulation become mandatory in 1978. Analysis of the age of housing stock in Napier and Hastings has a strong correlation between areas of high deprivation and areas which have the greatest proportion of pre 1978 homes. This equates to almost 33,000 houses with 83% of Housing New Zealand homes in Hawke's Bay built before 1978. Housing New Zealand is already undertaking a major insulation programme to address this. The Housing Coalition have found that landlords have had a poor uptake on insulation-retrofit programmes despite subsidies.

Setting the NESAQ based on health outcomes

There is no known threshold below which outdoor ambient PM₁₀ does not adversely impact upon human health. PM₁₀ is bad for health because it bypasses the nose and mouth and gets stuck in the lungs. This results in both minor and major adverse health outcomes ranging from nose and throat irritations to premature death. Research shows there is an increase in death rates when exposed to PM₁₀ in the short-term and an even greater increase in death rates when exposed to PM₁₀ in the long-term. There is little evidence on the proportion of Hawke's Bay death and hospitalisation rates that are attributable to outdoor air pollution. However, recalculation of data by Fisher et al (2007) calculated that approximately 27 premature deaths and 55 hospital admissions annually in Napier and Hastings are estimated to be due to outdoor air pollution. Hawke's Bay rates of bronchiolitis and whooping cough are higher than national rates; rates are particularly high amongst Pacific and Maori babies. The literature review indicated that given the data analysed (solely outdoor ambient air quality and the potential impact on health outcomes) the NESAQ appear to have been set appropriately by the Ministry for the Environment. Given the NESAQ was not attempting to determine impact on indoor air quality, any potential unintended effects on indoor air quality were not considered in setting the NESAQ. The literature review for this HIA

showed that there is unlikely to much difference between indoor and outdoor air pollution levels as the air from outside ends up inside sooner or later. The potential unintended indoor air quality impacts from the Plan Change on health may be both positive and negative, as described below.

Intended Effects on Outdoor Ambient Air Quality (PM₁₀) and Subsequent Direct and Indirect Impacts on Health and Wellbeing of the Proposed Air Quality Plan Change.

Potential positive impacts:

- i. New replacement burners must meet higher emission standards. This will lead to a decrease in outdoor PM₁₀ concentrations during winter months. There is a causal effect between short and long-term exposure to PM₁₀ and adverse health effects and many of these would be averted.
- ii. Positive effects of reduced outdoor PM₁₀ concentrations include increased activity days which in turn has the potential to lead to maintained or increased physical activity levels, maintained/increased social cohesion and maintained/increased access to education and employment.

Potential negative impacts:

- i. The financial cost of improving outdoor air quality in relation to PM₁₀; and of improving indoor air quality in relation to PM₁₀, temperature and moisture: is a major issue for many households in New Zealand. Many New Zealand households experience fuel poverty due to the increased cost of daily living, particularly low income households. The most cost effective appliances to operate are the most expensive appliances to purchase and install. Conversely, the cheapest appliances to purchase and install (i.e. unflued gas heaters, electric fan heaters) are the most expensive to operate (in the long-term). Many households cannot afford the substantial upfront cost required and may end up purchasing cheaper home heating appliances that cost more to operate, and are often also detrimental to their health via impact on indoor air quality. Unflued gas heaters are a particular concern as they are relatively inexpensive to purchase, yet

they are one of the most expensive home heating appliances to operate and they have known adverse health impacts.

- ii. If people perceive they have a lack of control about decisions in their own home this has the potential to lead to decreased self esteem.
- iii. Households with NESAQ compliant burners may still burn inappropriate materials such as plastics, treated timber, or wet wood – contributing to outdoor PM₁₀ concentrations in the air as well as emitting a variety of other contaminants.

Unintended Effects on Indoor Air Quality and Temperature; and Social Issues, and Subsequent Direct and Indirect Impacts on Health and Wellbeing.

(These relate to the Healthy Homes and Clean Heat Initiatives as described earlier)

Potential positive impacts:

- i. The phased prohibition of non-compliant solid fuel burners may create an opportunity for agencies to have a “wrap around” approach to support a healthy homes concept.
- ii. The phased prohibition of non-compliant solid-fuel burners has the potential to increase households’ awareness about healthy home environments, which in turn may encourage more homes to take a holistic approach to their homes impact on occupant health and wellbeing. For example, reducing the risk of non-fatal and fatal injuries from heating appliances.
- iii. Replacing non-compliant solid-fuel burners with compliant options could also lead to more efficient heating options being installed and hence warmer drier homes with less indoor air pollutants. Such changes could prevent/reduce chronic conditions such as sneezing and coughing, cancer and respiratory disorders (which can also be acute e.g., asthma attack). Indoor air quality is a concern in New Zealand because many homes are poorly insulated, cold and damp, and often have lower indoor air temperatures than houses in other comparative countries. Houses that are cold are more likely to be damp and mouldy, and this is exacerbated when home heating appliances that create moisture and condensation are used.

- iv. Replacing non-compliant solid-fuel burners with compliant options could also lead to more efficient heating options being installed and less operating financial costs to the household.

Potential negative impacts:

- i. The prohibition of solid-fuel burners significantly increases the likelihood that landlords (or home-owners) may not replace non-compliant heating sources, leading to tenants (or home-owners) using unflued LPG heaters as an alternative heating source. Unflued LPG gas heaters, while emitting very little particulate matter, are one of the most expensive types of home heating to operate, create a lot of indoor moisture, release dangerous gases into the home, lead to injury and fires in the home, and contribute to dampness in the home. These contribute to multiple negative health outcomes.
- ii. Workshop participants from the community indicated that by not having a warm home some people would be ashamed that their households were cold and they would not invite guests/visitors and this would lead to decreased social connectedness.
- iii. Household finances could be diverted into paying for household energy when that wasn't affordable, particularly if householders had previously had access to free fire-wood and now had a heat pump. This could lead to either heating not being used, or heating being traded-off with other necessities.
- iv. The number of homes that rely on electrical heating will increase, and if/when power cuts occur, unavailability of electrical heating will impact a larger number of people.

Recommendations

- 1. That the Hawke's Bay Regional Council and Hawke's Bay District Health Board should continue to support the Healthy Homes Coalition and the implementation and business plan for 2009-2012. The Strategic Housing Action Regional Priority 'SHARP' Focus 2009 report identified warmth (including heating and solar design) and air quality as areas of priority. There is also a primary objective in the SHARP report for insulation of homes and to facilitate the planned retrofitting of homes which meet specific criteria.

This SHARP report also recommends securing the resources for and establishing a “Healthy Homes Coordinator” position to ensure the priorities in the above implementation plan are coordinated and managed. Such positions have been set up around the country and those coordinators are willing to support initiatives in Hawke’s Bay with advice and guidance.

2. That the Hawke’s Bay Regional Council develop a holistic and “wrap around” approach with other agencies/organisations to implement the Plan Change and associated Clean Heat financial assistance programme. The financial assistance package that is proposed needs to be “user friendly” and specifically targeted at the low income groups in the Hastings and Napier airsheds. It is important that ongoing education is provided to other agencies/organisations (e.g. budget advisory services) who will be dealing with a significant increase in clients that need to assess the financial assistance packages.
3. That the Hawke’s Bay Regional Council develop a community education programme which focuses on new requirements of the Plan Change and raises awareness of the financial assistance packages. Key features of community education programme should be:
 - a) Homeowners and tenants should be informed of the number of choices about heating options to best suit their household so that they maintain a sense of control;
 - b) Provision of information and education programme needs to have a specific emphasis on:
 - i) the low income groups and “hard to reach areas” of the population;
 - ii) landlords and property managers as many of the highest risk groups to negative wellbeing outcomes are tenants.
 - c) Highlighting the health and safety and operating cost issues with unflued LPG heaters as these are known to cause negative wellbeing outcomes;
 - d) Other issues such as fire safety, insulation and appropriate materials to burn should also be covered;

- e) Investigate implementation of household energy assessments in Hawke's Bay as part of the Hawke's Bay Regional Council's holistic approach.
4. That the Hawke's Bay Regional Council works in partnership with the Health Promotion advisors at the Hawke's Bay DHB on how to implement community education programmes (as that is a particular skill set of theirs).
 5. That the Hawke's Bay Regional Council support manufacturers, carpet/curtain/wood banks in the Hawke's Bay region as these programmes complement the Clean Heat programme and will assist in delivering the full social and wellbeing benefits that will likely accrue.
 6. That the Hawke's Bay Regional Council work with appropriate agencies/organisations to develop and optimise local workforce and industry capacity as the scheme has the potential to retain, and to bring, substantial employment and technological innovation to the region.

History of Engagement

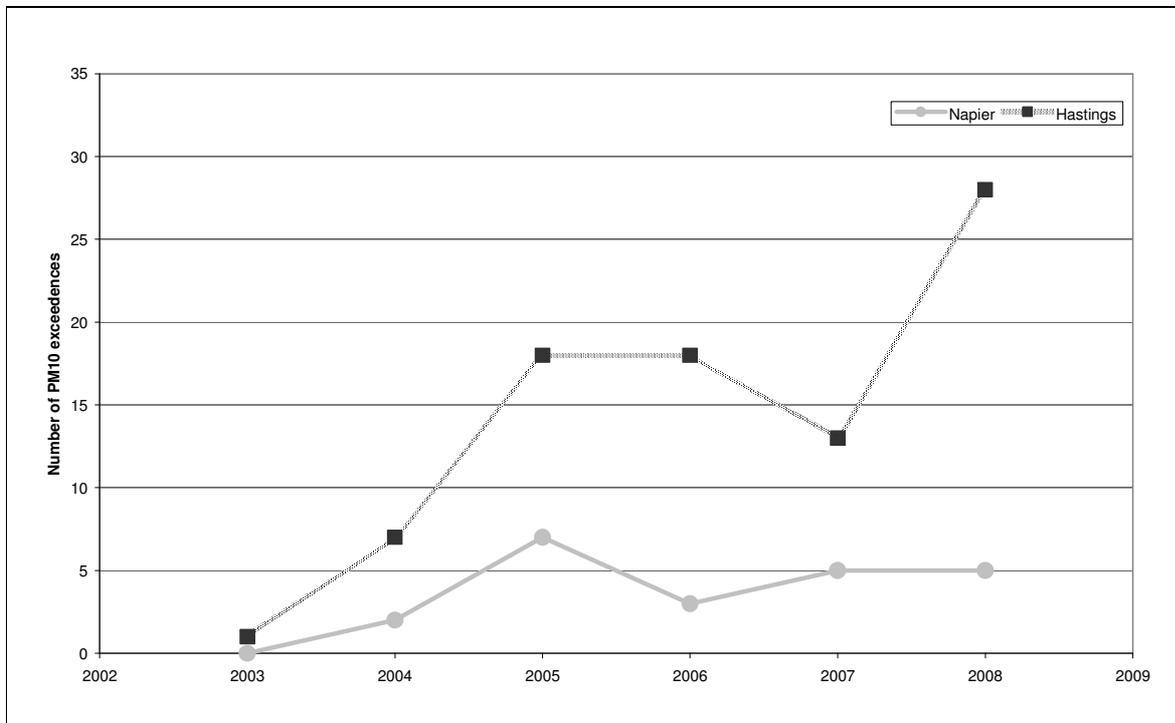
The Hawke's Bay Regional Council (HBRC) was invited to engage with the Hawke's Bay District Health Board (HBDHB) to conduct a health impact assessment (HIA) on the Proposed Air Quality Plan Change (Plan Change). The Hawke's Bay District Health Board is currently working with local government bodies to incorporate health impact assessment into a wide range of their planning processes. This was also supported by a successful application to the Ministry of Health's health impact assessment 'Learning by Doing Fund' which supports District Health Board's and Councils to adopt the tool by engaging 'experts' in this area to learn the process. The funding has therefore enabled Quigley and Watts consultants to facilitate the process and to mentor the staff on the Health Impact Assessment process.

Background

In 2004 it was the collective view of New Zealanders from business, local government and the wider community that New Zealand needed National Environmental Standards for Ambient Outdoor Air Quality (Ministry for the Environment, 2004). A National Environmental Standard for Ambient Outdoor Air Quality (NESAQ) in relation to PM₁₀ came into effect in 2005. The NESAQ for PM₁₀ was set allowing only one annual exceedance of an average daily level of 50 µg/m³ (50 micrograms of PM₁₀ per cubic metre of air) after 2013.

Within the Hawke's Bay region, PM₁₀ levels have been monitored in Napier since 2000 and in Hastings since 2003. During this period, both areas have generally exceeded the standard of no more than one exceedance per area per year (Figure 1).

Figure 1: Annual PM₁₀ Exceedances in Napier and Hastings



Source: Compiled from SOE reports²

The Hawke's Bay Regional Council is currently developing a local approach to comply with the standards. That local approach tackles the principal sources of PM₁₀ emissions in the Napier and Hastings Airsheds. Almost 90% of PM₁₀ concentrations in the Napier and Hastings Airsheds are due to solid fuel heating appliances in houses, yet according to the NESAQ, it would be industrial activities that would be impacted if PM₁₀ concentrations continued to exceed the NESAQ beyond 2013. The implicit rationale for this was that potential impacts on industrial activities would encourage Regional Council's to undertake effective action.

In December 2008, the Hawke's Bay Regional Council publicly notified a Plan Change that addressed PM₁₀ emissions from solid fuel heating appliances³ and outdoor burning within the Napier and Hastings airsheds. Key features⁴ of the proposed Plan Change are:

² <http://www.hbrc.govt.nz/ReadAboutIt/StateofEnvironment/tabid/247/Default.aspx>, and

- from 2011, all open fires and burners that do not comply with the NESAQ installed before 31 December 1995 will be prohibited from use;
- from 2012, all burners that do not comply with the NESAQ installed before 31 August 2005 will be prohibited from use;
- from 2013, all burners that do not comply with the NESAQ will be prohibited from use;
- all new and replacement solid fuel burners in the Hastings Airshed must meet an emission rate of 0.7 grams of PM₁₀ for each kilogram of wood burned;
- all new and replacement solid fuel burners in the Napier Airshed must meet an emission rate of 1.5 grams of PM₁₀ for each kilogram of wood burned;
- after the ownership of a property has been transferred (eg: sale of a house) any burner that does not comply with the NESAQ can no longer be used; and
- resource consent is required to undertake outdoor burning during May – August (inclusive).

The health impact assessment considers how the Plan Change might impact either positively or negatively on the health and wellbeing of people in Hawke’s Bay. It also aims to gather evidence about the proposed change, and make constructive recommendations about how the proposed rules and any future implementation programme may be improved.

Health Impact Assessment

Health Impact Assessment (HIA) is a multidisciplinary approach that investigates the potential public health and wellbeing outcomes of a proposal. Its aim is to deliver evidence based recommendations that inform the decision-making process, to maximise gains in

³ <http://www.hbrc.govt.nz/ReadAboutIt/StateofEnvironment/MonthlySOEReports/tabid/795/Default.aspx>
Solid fuel heating appliances refers to wood and coal heating appliances such as open fires, wood burners, and pellet fires (Fisher et al, 2007).

⁴ Some of these key features of the Plan Change have been submitted on by the HBRC itself. That submission seeks alterations to key features and phase-out dates applicable to solid fuel burners. The HBRC submission will be considered by a Hearings Panel in late 2009, alongside almost 200 other submissions.

health and wellbeing and to reduce or remove negative impacts or inequalities. HIA uses the broad definition of health used by the World Health Organization:

“Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.”

HIA is an internationally recognised approach that helps to protect and promote community wellbeing and public health.

The key reasons to undertake a Health Impact Assessment are:

- To help policy makers use a sustainable development approach
- To assist policy makers meet public health requirements of legislation and policy direction such as the Local Government Act (2002) and the Land Transport Management Act (2002)
- To help policy-makers incorporate evidence into policy-making
- To promote cross-sectoral collaboration
- To promote a participatory, consultative approach to policy-making
- To improve health and wellbeing and reduce inequalities in health
- To help policy-makers consider Treaty of Waitangi implications

HIA Process Used

The Health Impact Assessment process followed standard methodology as described in the document “A Guide to Health Impact Assessment: A policy tool for New Zealand”. It is usual within an HIA to compare one proposed option against another, either comparing a proposal with business as usual or comparing various proposed options available. In this instance, we compared the status quo (ie: no restrictions on solid fuel heating appliances and outdoor burning) with the Plan Change developed by the Hawke’s Bay Regional Council.

The four key stages in a Health Impact Assessment process are:

- Screening
- Scoping
- Appraisal
- Evaluation/Reporting

Screening

Screening is the initial selection process to assess a policy's suitability for health impact assessment. The screening for the Plan Change HIA was undertaken by a small team from the Hawke's Bay District Health Board. This process showed that it would be appropriate to undertake a HIA on the Plan Change.

Scoping/setting the priorities of the HIA

Scoping highlights the key issues that need to be considered and sets out what will be done in the HIA. The scoping meeting was held with a group of key people at the Hawke's Bay Regional Council on the 21st January 2009 and was facilitated by Robert Quigley from Quigley and Watts, and Ana Apatu and Maree Rohleder from the Hawke's Bay District Health Board. A full copy of the scoping report (including the determinants of wellbeing and population group discussions) is available from the authors

It was decided to concentrate on the replacement/removal of heating sources, including both the ongoing costs/impacts and the one off costs/impacts on the low income population group. This decision was taken because it was the component most able to be influenced at this stage in the Strategy development, and the implementation of this component covers important issues for Council and the community such as subsidies.

From the scoping meeting the group made the following recommendations about the HIA and its scope:

Aim

To inform the decision makers of the potential positive and negative health and wellbeing impacts of the Plan Change.

Objectives

- Enhance partnership working between the Hawke's Bay Regional Council and Hawke's Bay DHB through shared planning and resourcing.
- Assist the Hawke's Bay Regional Council to build on the positive aspects of the strategy and reduce any unintended negatives impacts and hence develop a well rounded strategy.
- To build capacity for Hawke's Bay District Health Board and Hawke's Bay Regional Council staff to use HIA in Hawke's Bay.
- To gather evidence about how the National Environmental Standards have been set and how outdoor PM₁₀ affects health.
- To gather evidence about how different types of home heating appliances affect indoor air quality in relation to PM₁₀, temperature and moisture, and to gather evidence about the financial cost of home heating appliances
- To support the Hawke's Bay Regional Council's consultation process with the community
- To provide recommendations on the implementation of the Clean Heat Strategy from the HIA process to inform the decision makers
- To disseminate the HIA findings into the wider policy arena of all relevant agencies.

Determinants of Wellbeing and Health

It was not considered possible to undertake a HIA on all of the determinants potentially affected by the proposal due to the limited time and resources available for the HIA. The group therefore decided to focus on the following determinants:

1. Financial Impact on the household economy

- Cost of compliance
- Cost of heating
- Renters – rise in rent, landlords not providing any heat

- Reliance on WINZ benefits
- Having to make financial choices i.e. food or heat.

2. Indoor Environment

- Temperature/cold
- Damp
- Social effects
- Replacement of heating source e.g. use of LPG heaters.

Population Groups of Interest

The Scoping Group decided that the population group that the HIA should focus on was low income.

Appraisal

The aim of this stage was to appraise the Plan Change's potential to affect wellbeing and population health, if the strategy is implemented as outlined in the draft. This stage also determined what practical changes could be made to the policy to promote and protect wellbeing and health.

For this HIA several sources of evidence were used to assist in undertaking the appraisal.

These were:

- Review of key documents (undertaken by Quigley and Watts)
- Community profile
- Interviews and workshops with community and key stakeholder groups
- Scan of relevant policy and strategy documents.

Appraisal Findings

The full review of key literature documents is available in Appendix One. A summary is as follows:

The review of key documents explains how the standards were set, how outdoor PM₁₀ levels impact health outcomes, how home heating appliances affect indoor air quality and health and the financial impact of home heating appliances.

Setting the National Environmental Standards for Air Quality

- In the National Environmental Standards for Air Quality (2004), the Ministry for the Environment set outdoor ambient air quality concentrations of PM₁₀ on an average daily threshold basis.
- The reason behind applying an average daily threshold as opposed to an average annual concentration limit is that many regions exceed the threshold in winter and not in summer. This means those regions could have had PM₁₀ discharges below an average annual threshold but still have had some PM₁₀ discharges above an average daily threshold. Enforcing average annual emissions only would not identify such short-term exceedances.
- An average daily threshold relates to acute health effects rather than an average annual threshold which relates to chronic health effects.
- There is no known threshold below which PM₁₀ does not adversely impact upon health.
- From a health perspective relevant to outdoor air quality, the NESAQ for PM₁₀ has been set appropriately by the Ministry for the Environment. Given the NESAQ was not attempting to determine impact on indoor air quality or social/economic issues, any potential unintended positive or negative effects on these issues were not considered in any significant detail when setting the NESAQ.

Outdoor PM₁₀ and Health

- PM₁₀ is bad for health because it bypasses the nose and mouth and gets stuck in the lungs. This results in both minor and major adverse health outcomes ranging from nose and throat irritations to premature death.
- Short-term exposure tends to lead to acute effects while long-term exposure tends to lead to chronic effects.
- Both national and international shows there is an increase in death rates when exposed to PM₁₀ in the short-term and an even greater increase in death rates when exposed to PM₁₀ in the long-term.
- While there have been few epidemiological studies undertaken in New Zealand, the results from one study in particular showed that the combined effect on daily mortality of up to 40 preceding days' exposure may be much greater than the single-day effect.
- There is little evidence on the proportion of Hawke's Bay death and hospitalisation rates that are attributable to air pollution. However, McElnay calculated that approximately 27 deaths and 55 hospital admissions (for chronic obstructive pulmonary disease and other respiratory admissions) in Napier and Hastings are estimated to be due to air pollution annually.
- While there are gaps in the research, national and international studies consistently found an association between outdoor PM₁₀ concentrations and adverse health outcomes.

Home Heating Appliances and Indoor Air Quality and Health Outcomes

- Home heating appliances affect indoor air quality in relation to PM₁₀, temperature and moisture. This in turn affects health outcomes by causing and/or aggravating chronic conditions such as sneezing and coughing, cancer and respiratory disorders (which can also be acute e.g. fatal asthma attack) to acute conditions such as fatal injuries.
- Indoor air quality is a concern in New Zealand because many homes are badly insulated, cold and damp, and often have lower indoor air temperatures than houses in other countries.

- Houses that are cold are more likely to be damp and mouldy, and this is exacerbated when home heating appliances that create moisture and condensation are used.
- Some research indicates that pollution levels inside the home are often similar to pollution levels outside the home due to PM₁₀ discharged from solid fuel home heating appliances.
- The risks to health are further compounded as indoor pollutants have as much as a 1000-fold greater chance of being inhaled than outdoor pollutants.
- There are currently no standards for indoor air quality in New Zealand. The National Environmental Standards for Air Quality (the standards) apply to outdoor air quality alone.

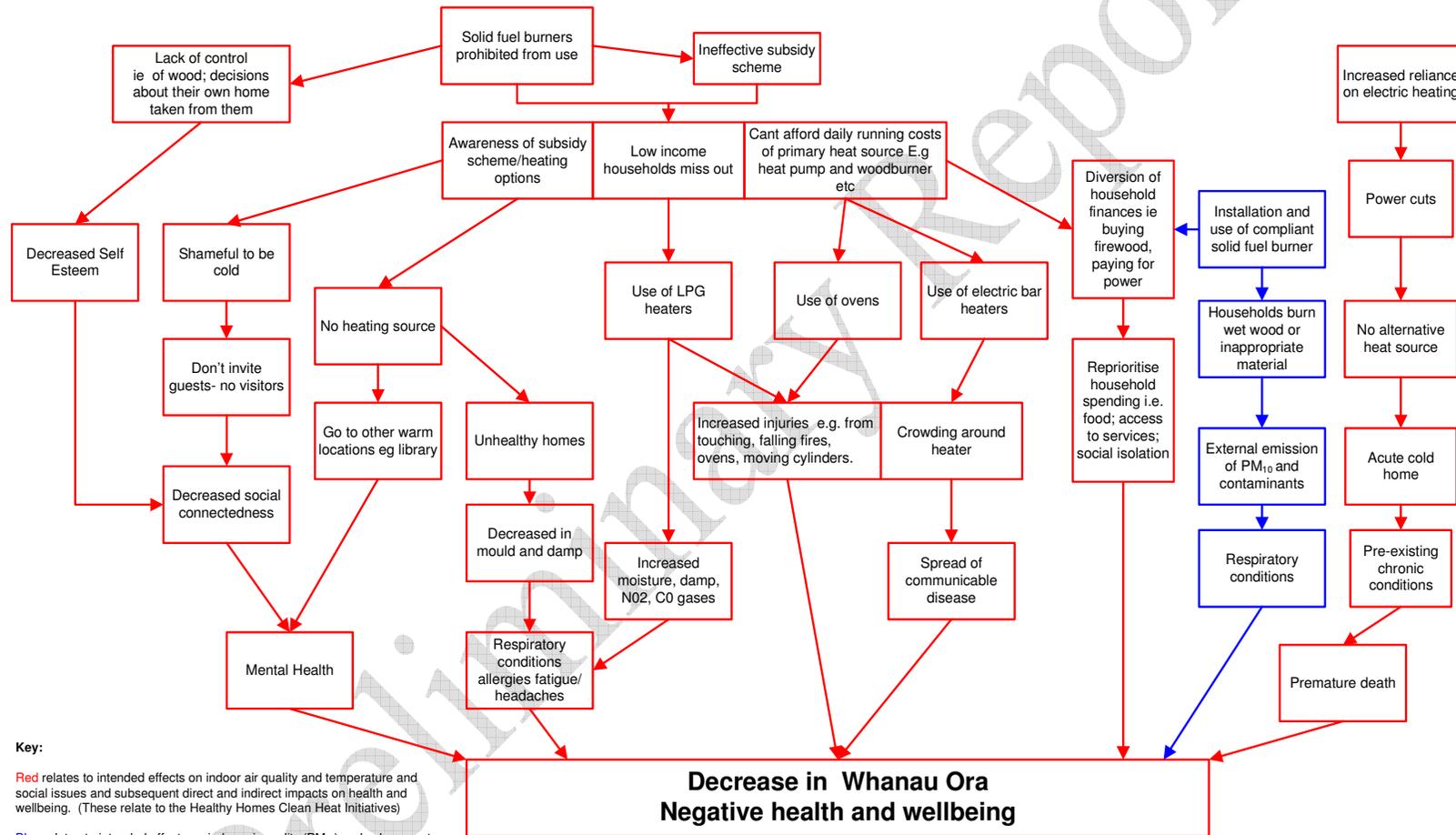
Financial Costs of Installing and Operating Home Heating Appliances

- Indoor air quality and temperature is a major issue for many households in New Zealand. However the financial barriers regarding one-off up-front costs for such improvements are considerable.
- Many New Zealand households experience fuel poverty due to the increased cost of daily living, particularly low income households.
- The most cost effective appliances to operate are the most expensive appliances to install. Conversely, the cheapest appliances to install (i.e. unflued gas heaters, electric fan heaters) are the most expensive to operate (in the long-term).
- Many households cannot afford the substantial upfront cost required and end up purchasing cheaper home heating appliances that cost more to operate. These cheaper appliances are often detrimental to occupants' health due to creation of indoor moisture and other by-products of the combustion/heating process.
- Unflued gas heaters are a particular concern as they are relatively inexpensive to purchase, yet they are one of the most expensive home heating appliances to operate and they have known adverse health impacts.

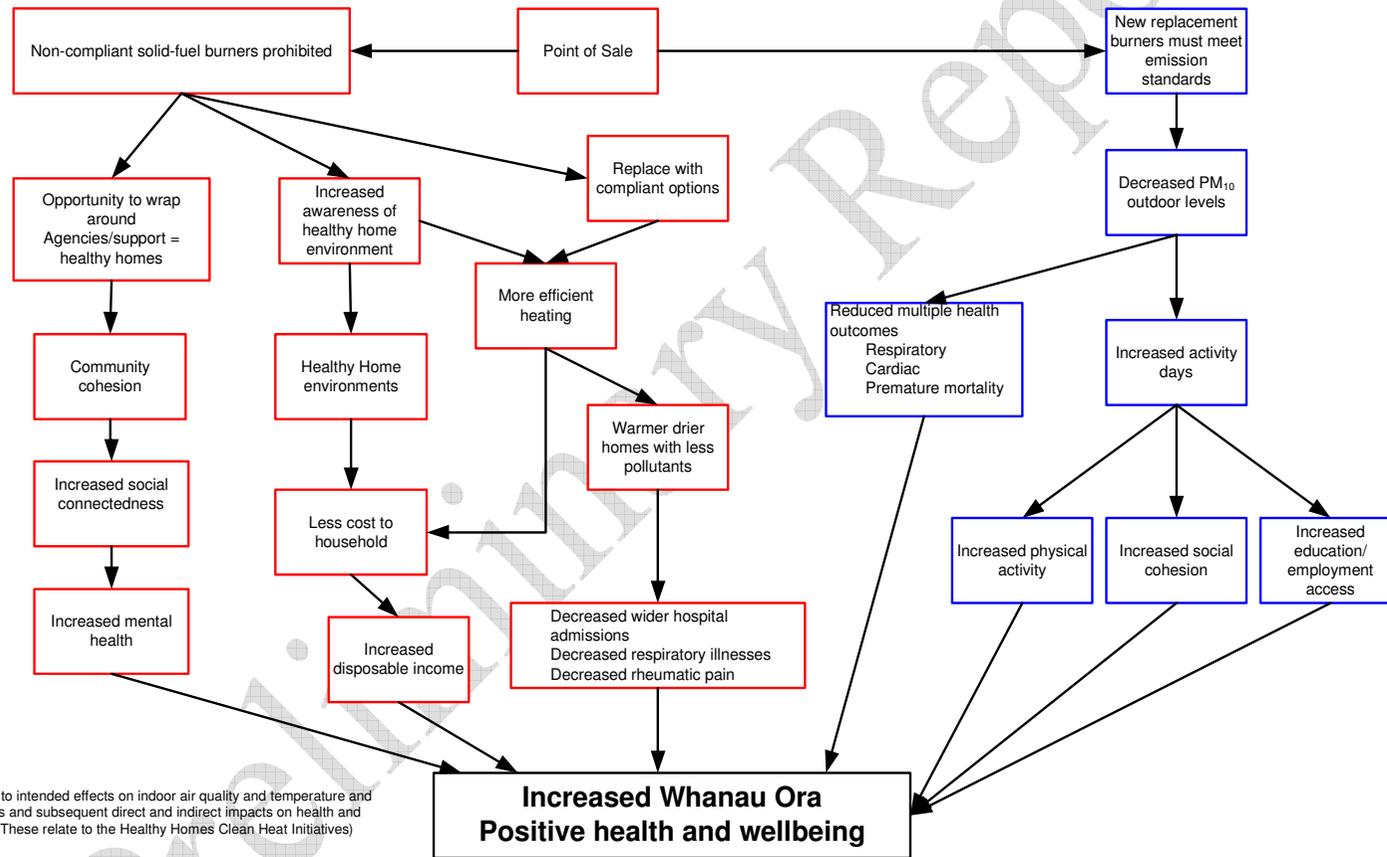
Causal Pathways

Evidence from the stakeholder meetings and the literature review has been summarized in the following causal pathways. The pathways show potential intervention steps to enhance the positive and reduce the negative aspects of the Plan Change and related aspects of the Clean Heat Initiative. These pathways are discussed more fully later in the document.

Clean Heat (Negative)



Clean Heat (Positive)



Key:

Red relates to intended effects on indoor air quality and temperature and social issues and subsequent direct and indirect impacts on health and wellbeing. (These relate to the Healthy Homes Clean Heat Initiatives)

Blue relates to intended effects on indoor air quality (PM₁₀) and subsequent direct and indirect impacts on health and wellbeing of the Proposed Air Quality Plan change

Discussion

In Aotearoa/New Zealand and internationally there is increasing recognition of the role that various social, economic, environmental and political factors play in determining the health experiences and outcomes for individuals and social groups. These factors include such determinants as income, employment status, housing, education, social position and social exclusion. They can have both direct and indirect impacts on health as well as having interrelated and cumulative effects over lifetimes.

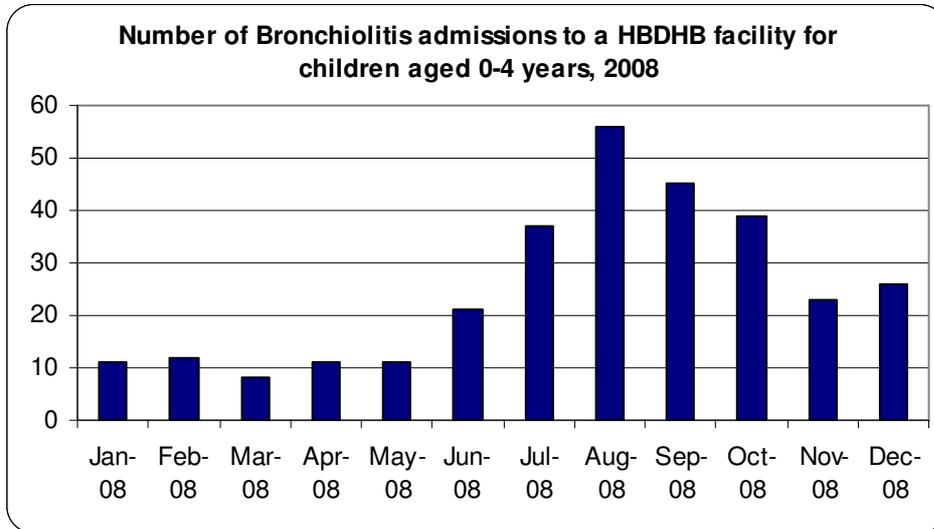
Poor health, like poor education, holds back many people. Moreover, the cycle of poor health, unemployment and poverty compounds over a person's life. (Ministry of Health 2002)

It is therefore important to concentrate on upstream measures and interventions that impact on these determinants of wellbeing, three of which are the quality of outside air, the warmth and dryness of homes and the cost of home heating. There is clear evidence that the factors which influence wellbeing are not equally distributed between Maori and non-Maori and this is the main cause of higher death and disability rates for Maori.

The following statistics relate to Hawke's Bay housing:

- Sixty seven percent of privately owned homes in Hawke's Bay were built before insulation became mandatory in 1978. This equates to almost 33,000 houses with 83% of Housing New Zealand homes in Hawke's Bay built before 1978. Housing New Zealand is undertaking a major insulation programme to address this.
- Analysis of the age of housing stock in Napier and Hastings has a strong correlation between areas of high deprivation and areas which have the greatest proportion of pre 1978 homes.
- Hawke's Bay rates of bronchiolitis and whooping cough are higher than national rates; rates are particularly high amongst Pacific and Maori babies.

Figure 2: Bronchiolitis admissions to a HBDHB facility for children aged 0-4 years, 2008



Source: HBDHB Data Warehouse

The relationship between income and health has been reviewed extensively elsewhere (National Health Committee, 1998) and that in general, lower incomes are associated with high morbidity and mortality for many illnesses and injuries.

The relationship between the quality of the indoor environment and health outcomes is well described by the review of key documents. Colder houses place more physiological stress on older people, babies and sick people who have less robust thermoregulatory systems and are also likely to spend more time inside (Howden-Chapman et al, 2007). There is increasingly clear evidence for the connection between colder weather and an increased winter hospitalisation rate in countries with lower standards of housing energy efficiency and heating. (Howden-Chapman et al, 2009)

The causal pathways which summarises the evidence that was gathered for this HIA report as described previously will now be discussed further, under the following categories:

- Intended effects on outdoor ambient air quality (PM₁₀) and subsequent direct and indirect impacts on health and wellbeing of the Proposed Air Quality Plan Change.
- Unintended effects on indoor air quality and temperature; and social issues, and subsequent direct and indirect impacts on health and wellbeing.

Intended Effects on Outdoor Ambient Air Quality (PM₁₀) and Subsequent Direct and Indirect Impacts on Health and Wellbeing Of The Proposed Air Quality Plan Change.

Potential Positive Impacts

New replacement burners must meet emission standards

This pathway commences with “New replacement burners must meet emission standards” which is known to lead to a decrease in outdoor PM₁₀ levels. During winter over 20,000 solid fuel burners in Hastings and Napier contribute to just under 90% of the PM₁₀ emissions in these airsheds.⁵

The literature review (see Appendix 1) indicates that there is a causal effect between short and long-term exposure to PM₁₀ and adverse health effects. These health effects can include respiratory illness, cardiac illness and premature death. The health effects seem to fall disproportionately on the most at risk groups e.g. young children, infants, elderly, people with existing respiratory and cardiovascular conditions/diseases, asthmatics and people from lower socioeconomic groups. Therefore the decrease in outdoor PM₁₀ levels will lead to two positive health outcomes – reduced death and disability, and increased activity days. Activity days are reduced with PM₁₀ exposure as many people become so unwell that they cannot go about their usual business be that work, school, caring or play. The Plan Change is intended to reduce outdoor PM₁₀ levels, therefore the Plan Change will also lead to positive health outcomes – namely reduced mortality and disability, and increased activity days.

Increasing activity days has the potential to lead to maintained or increased physical activity levels, maintained/increased social cohesion and maintained/increased access to education and employment.

⁵ Other sources of PM₁₀ include aviation, motor vehicles, outdoor burning, industry and natural sources.

Potential Negative Impacts

Decreased Self Esteem

The participants at the appraisal workshops advised that if people perceive they have a lack of control about decisions in their own home this has the potential to lead to decreased self esteem. The effects of lack of control and decreased self esteem on health are explained in the following quote:

Continuing anxiety, insecurity, low self esteem, social isolation and lack of control over work and home life have powerful effects on health. Such psychological risks accumulate during life and increase the chances of poor mental health and premature death. (Wilkinson R, Marmot M, 2003)

Solid-fuel burners prohibited from use

The next potential negative pathway which was discussed by the stakeholders was with the prohibition of solid-fuel burners leading to some landlords or owners not replacing the main heating source due to cost issues. This has the potential to cause a decrease in temperature and an increase in dampness and mould in the home. The literature review confirms that indoor air temperature is linked to indoor moisture because houses that are cold are more likely to be damp and mouldy. Such outcomes have the potential to negatively affect mental health, respiratory conditions and hospital admissions.

With the prohibition of solid-fuel burners another pathway from this change is that households have an increased likelihood of using unflued LPG heaters as an alternative heating source. Unflued LPG heaters are relatively inexpensive to purchase, the costs are not borne by the landlord and they are perceived by some people in the community to be cheap to run. Unflued LPG gas heaters are actually one of the most expensive types of home heating to operate and are about the same cost as running an electric fan heater (Consumer 2002). This goes against many people's perceptions that unflued gas heaters are cheap to run (Gordon, 2009). Unflued LPG gas heaters can also create a lot of indoor moisture and the water vapour released during the

combustion process contributes to dampness in the home (Howden-Chapman, 2008). Excess moisture then results in condensation and the spread of mould.

Mould has been attributed to causing or contributing to various negative health and wellbeing outcomes including:

- Irritations of the throat and eyes
- Allergies (more frequently allergic rhinitis)
- Lower respiratory symptoms (dry or productive cough, wheeze)
- Asthma
- Increased incidence of respiratory infections
- General Symptoms like fatigue, headache, dizziness and difficulties in concentration

(World Health Organization, 2004)

Rooms with unflued gas heaters have also been found to have higher concentrations of nitrogen dioxide than rooms with electric or flued heaters (Howden-Chapman et al 2008). Nitrogen dioxide is a proinflammatory gas and can exacerbate respiratory symptoms such as wheeze or cough. It can reduce immunity to lung infections and increase the severity and duration of an episode of the flu (Howden-Chapman et al 2008). These lead to negative health and wellbeing

Burning wet wood or inappropriate material

Workshop participants' described that achieving reducing PM10 emissions from solid fuel burners is dependent on the household burning dry wood, and not burning other inappropriate material such as plastics or treated timber. Respiratory conditions have the potential to be maintained unless households have access to dry firewood at appropriate prices. The literature review commented that:

'Modern appliances are designed to ensure combustion of all gases and particles takes place within the firebox to maximise heat output and to minimise discharge of particulate emissions to the atmosphere' (New Zealand Home Heating Association, 2002:7). However, this relies on the person operating the fire e.g. they must ensure the wood is dry because if the wood is wet, excess smoke can be produced both indoors and outdoors.

Unintended effects on indoor air quality and temperature; and social issues, and subsequent direct and indirect impacts on health and wellbeing.

(These relate to the Healthy Homes and Clean Heat Initiatives as described earlier)

Potential Positive Impacts

Prohibition of non-compliant solid fuel burners

There are six main pathways identified that may positively influence health and wellbeing. The first pathway shows that the prohibition of non-compliant solid fuel burners may create an opportunity for agencies to have a “wrap around” approach to support a healthy homes concept.

This was supported by the Hawke’s Bay Regional Council and other agencies involved in the appraisal workshops. In the Hawke’s Bay region, the Hawke’s Bay Healthy Homes Coalition (HBHHC) has been formed which has a range of partners from Government, NGO’s, Mana Whenua and other key local government stakeholders. The Coalition has recently released a Hawke’s Bay Healthy Homes Strategy - *Not Leaving it to Chance* which has been developed to deliver a sustainable, integrated and strategic approach to ensuring all people of Hawke’s Bay have access to affordable, safe and appropriate housing. One of its objectives is:

“Ensuring air quality in homes... by ensuring sources of heating meets air quality standards.”

A healthy home is known to increase the health and well being of its occupants – increasing their capacity to contribute as productive members of the community (HBHHC strategy 2008). Such a programme has the potential to strengthen community cohesion and promote social connectiveness.

Secondly, the prohibition of non-compliant solid-fuel burners and associated publicity initiatives have the potential to increase households’ awareness about healthy home environments, which in turn may encourage more homes to take a holistic approach to their homes impact on the whanau. This may encourage more efficient heating, lower costs for the household heating and/or warmer/drier homes with less pollutants. The literature review highlighted that occupant

behaviour is also a contributing factor to home heating appliances discharging PM₁₀, having low indoor air temperature and high levels of moisture. Occupant behaviour can also result in households spending more money on home heating because they are not using their home heating appliances efficiently.

One stakeholder also commented on potential employment options because of the new strategy:

With a significant number of fireplaces to be replaced in a short period of time - is there a business / employment opportunity available? Could unemployed be trained now to become installers or inspectors? Is there going to be a door knocking campaign handing out pamphlets? This would be another employment opportunity?

The reversal of such effects via increased awareness of a healthy home environments may generate savings to the household and mean more disposable income would be available.

Replacing non-compliant solid-fuel burners with cleaner heating options could also lead to more efficient heating options being installed and hence warmer drier homes with fewer pollutants and less financial cost to the household. The review of key documents was clear that

“Houses that are cold are more likely to be damp and mouldy and this is exacerbated when unflued gas heaters are used as they create more moisture and condensation.”

Finally, the pathways above have the potential for substantial health and wellbeing gains:

“Potentially [the] health benefits of installing better heating can accrue in a number of ways, such as a reduced number of visits to general practitioners, hospitalisations, days off school and days off work” (Howden-Chapman, 2006)

This can lead to a decrease in wider hospital admissions, respiratory illness and rheumatic pain, which will mean a positive health and wellbeing outcome. The literature review also discusses the link between colder weather and hospitalisations:

“There is clear evidence for the connection between colder weather and an increased winter hospitalisation rate in countries with lower standards of housing energy efficiency and heating such as New Zealand. Many winter deaths are due to colder temperatures.”

“The World Health Organization also links rheumatic pain to humidity and temperature.” (World Health Organization, 2004)

Potential Negative Impacts

Lack of control

The participants at the appraisal workshops advised that if people perceive they have a lack of control about decisions in their own home this has the potential to lead to decreased self esteem. These participants also indicated that by not having a warm home some people would be ashamed that their households were cold and they would not invite guests/visitors and this would lead to decreased social connectedness.

Cold houses also discourage the formation of social networks which are important for mental health as well as affecting mortality (Hopton et al, 1996)

It was also discussed that by not having a heating source people would go to other warm locations e.g. library. All of these pathways have the potential to lead to a decrease in people’s mental health and a negative health and wellbeing impact.

Studies have shown a clear correlation between substandard housing and mental health, with independent contributions to feelings of hopelessness, social isolation and stress (Auckland Public Regional Health Service, 2005). Kearns et al in 1993 found that the mental wellbeing of people with psychiatric conditions was correlated with the quality of their housing. Poor housing, lack of money and limited social contact contributes to depression and anxiety in this population and made them more likely to be re-hospitalised. Kearns also found that living in a substandard house is an independent and additional source of stress for people on low incomes and said ‘ the

despair among these populations cannot be adequately described in a series of statistical tables and conceptual diagrams' (Kearns, et al, 1993)

The participants at the appraisal workshops also provided evidence of people, especially the elderly, who use unflued LPG gas heaters to support themselves as they get in and out of chairs/couches. The Napier fire service has also described that such incidents have been known to occur in Napier/Hastings. The unflued LPG heaters become unstable and can cause injury to the person. Where ovens are used as an alternative heating source (because a primary heating source is too costly or not available) participants and the fire service confirmed there was an increased risk of injury from burns and there is a potential fire danger. Similarly the fire service has confirmed that electric bar heaters are a high fire risk and have caused several fires in Napier/Hastings, especially when the bar heaters are used in bedrooms.

The risk of fire is increased by poorly installed or faulty stoves and heating sources and families who have had the electricity disconnected may use candles which are a fire hazard. Burn injuries from fire happen less frequently than burns from hot substances, but are responsible for a higher number of fatalities. From 2000-2004, 25 New Zealand children under the age of ten died from being burnt by fire or flame, an average of five each year (Childhood Burn Injury Factsheet, Safekids New Zealand 2008).

Diversion of household finances

Concerns were expressed by the participants at the appraisal workshop (and backed up by the review of key literature documents) that household finances could be diverted into paying for household energy when that wasn't affordable, particularly if householders had previously had access to free fire-wood and now had a heat pump. One stakeholder commented:

Will fire places be replaced by heat pumps? It could be an unpleasant surprise via the power bill for some, as firewood can often be a cheap / free commodity for households. For instance some charities supply firewood to the elderly who can't afford it because they (the charities) get the firewood / trees donated to them. The charities are not likely to be in a position to hand out cash to meet power bills.

Clearly the financial impact on individuals will be a major issue and if there is not a full subsidy / loan available then this could make it very difficult.

The financial cost of improving indoor air quality in relation to PM₁₀, temperature and moisture is a major issue for many households in New Zealand. New Zealanders struggle to adequately heat their homes and pay for life's other necessities partly because of the cost of electricity: *'the price of residential electricity has risen considerably faster than the rate of inflation'* (Howden-Chapman et al, 2009:5). Residential electricity rates have also risen faster than commercial or industrial rates. Not surprisingly, there is a high disconnection rate in New Zealand and many households fall behind in paying their power bills (Howden-Chapman et al, 2009). *'Home heating and quality of insulation are essential for a healthy indoor climate...but the cost of heating can lead some families to heat inadequately or use inefficient and polluting heating systems'* (Fisher et al, 2007:8).

Stakeholders advised that information needs to be available in many languages including braille and it would be useful to disseminate information via Disability groups, Health groups (like Asthma society), Radio Kidnappers, Age Concern etc. as many in the disadvantaged sector will struggle to gain information from mainstream press. Budget services could perhaps also be separately advised of the exact financial assistance available. They also suggested a series of local community gatherings to discuss details.

Fuel poverty is a term used to describe households that *'need to spend 10% or more of [their]...(disposable) income on household energy, including heating the house to acceptable [World Health Organization] levels'* (Howden-Chapman et al, 2009:3). Heating can then become a trade off with other necessities i.e. households may spend less on food in order to keep their house warm. More people tend to experience fuel poverty in colder regions than people living in warmer regions; 26-31% of Dunedin households were in fuel poverty compared to 6-8% of households in Auckland (Howden-Chapman et al, 2009). On average, 10-14% of New Zealand households were in fuel poverty in 2001 (ibid).

Those most at risk of experiencing fuel poverty are those on low incomes: '*expenditure on electricity follows a social gradient, with the lowest decile paying the highest proportion of their income on electricity...[and] the disparities may be increasing*' (Howden-Chapman et al, 2009). People who are renting are also at risk of experiencing fuel poverty as they also tend to be on low incomes and cannot afford to buy their own home. In addition, rental properties tend to have fewer fixed heating appliances such as heat pumps and the houses tend to be older. One stakeholder queried:

What happens if you are renting a property - what are your rights, obligations etc. when dealing with your landlord? For instance- how can you ensure that your landlord is aware of the issue? What if the landlord simply refuses to replace (say) an open fire? What if the landlord passes on the loan cost to the tenant? Is it the responsibility of the property occupier to ensure compliance?

This reprioritisation of household finances to pay for the costs of household energy or the inability to pay the electrical bills means that households are less able to afford the necessities of life as discussed above. They could also be unable to afford access to services e.g. Doctors, Dental care etc and become socially isolated all of which has a negative health and wellbeing outcome. One stakeholder commented:

Overall it is likely that the NGO sector will become involved in this matter if the community does not fully understand its obligations, rights and options. Unfortunately with such a complex matter it is almost inevitable that many people will fail to understand and they will often turn to an NGO for advice, financial assistance or to complain about being poorly informed. It is of particular concern that many of these will be elderly and there may be a case for a specific strategy for this sector.

Increased reliance on electric heating

The last pathway describes households who are reliant on electrical household heating having the potential to be significantly affected by power cuts and having no alternative heating source. This could then lead onto cold homes, a worsening of pre-existing chronic conditions with the

potential for multiple negative health outcomes including premature death. Participants described that low income households and vulnerable population groups would be more adversely affected:

Maintenance of heat pumps is difficult for the elderly

Reduced enjoyment and comfort from fires

Power bills increased

The literature does not describe temporary loss of power (e.g. due to system outages) leading to additional negative health outcomes, but it is clear that winter by itself increases death rates.

“Many winter deaths are due to colder temperatures. This is known as excess winter mortality (EWM). The results indicate that New Zealand experiences a similar EWM to the United Kingdom; an average of 1600 excess winter deaths (Howden-Chapman et al, 2009:3). These cannot all be attributed solely to indoor temperature but that does seem to be a key contributing factor.” (Howden-Chapman et al, 2009)

Limitations

The following limitations for this Health Impact Assessment are noted by the team when preparing this report:

Timeframes

We had limited timeframes in which to undertake the workshops and complete the report in a timely manner so it would be beneficial to the decision makers. Due to this constraint we were not able to do in-depth consultation with the real estate sector, property managers and landlords, etc.

Scope

This Health Impact Assessment report had a limited focus as described above and does not discuss aspects of the clean heat initiative (e.g. financial assistance packages) which could be offered by the Hawke's Bay Regional Council.

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Recommendations

1. That the Hawke's Bay Regional Council and Hawke's Bay District Health Board should continue to support the Healthy Homes Coalition and the implementation and business plan for 2009-2012. The Strategic Housing Action Regional Priority 'SHARP' Focus 2009 report identified warmth (including heating and solar design) and air quality as areas of priority. There is also a primary objective in the SHARP report for insulation of homes and to facilitate the planned retrofitting of homes which meet specific criteria. This SHARP report also recommends securing the resources for and establishing a "Healthy Homes Coordinator" position to ensure the priorities in the above implementation plan are coordinated and managed. Such positions have been set up around the country and those coordinators are willing to support initiatives in Hawke's Bay with advice and guidance.
2. That the Hawke's Bay Regional Council develop a holistic and "wrap around" approach with other agencies/organisations to implement the Plan Change and associated Clean Heat financial assistance programme. The financial assistance package that is proposed needs to be "user friendly" and specifically targeted at the low income groups in the Hastings and Napier airsheds. It is important that ongoing education is provided to other agencies/organisations (e.g. budget advisory services) who will be dealing with a significant increase in clients that need to assess the financial assistance packages.
3. That the Hawke's Bay Regional Council develop a community education programme which focuses on new requirements of the Plan Change and raises awareness of the financial assistance packages. Key features of community education programme should be:
 - Homeowners and tenants should be informed of the number of choices about heating options to best suit their household so that they maintain a sense of control;
 - Provision of information and education programme needs to have a specific emphasis on:

- the low income groups and “hard to reach areas” of the population;
 - landlords and property managers as many of the highest risk groups to negative wellbeing outcomes are tenants.
 - Highlighting the health and safety and operating cost issues with unflued LPG heaters as these are known to cause negative wellbeing outcomes;
 - Other issues such as fire safety, insulation and appropriate materials to burn should also be covered;
 - Investigate implementation of household energy assessments in Hawke’s Bay as part of the Hawke’s Bay Regional Council’s holistic approach.
4. That the Hawke’s Bay Regional Council work in partnership with the Health Promotion advisors at the Hawke’s Bay DHB on how to implement community education programmes (as that is a particular skill set of theirs).
 5. That the Hawke’s Bay Regional Council support manufacturers, carpet/curtain/wood banks in the Hawke’s Bay region as these programmes complement the Clean Heat programme and will assist in delivering the full social and wellbeing benefits that will likely accrue.
 6. That the Hawke’s Bay Regional Council work with appropriate agencies/organisations to develop and optimise local workforce and industry capacity as the scheme has the potential to retain, and to bring, substantial employment and technological innovation to the region.

Glossary

µg/m³ or microgram per cubic meter is how scientists measure the amount of chemical vapours, fumes, or dust in the ambient air.

Airshed:

a) The region of a Regional Council excluding any area specified in a notice under paragraph b),

b) a part of the region of a Regional Council specified by the Minister for the Environment by notice in the Gazette to be a separate airshed.

(from Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins, and Other Toxics) Amendment Regulations 2004).

Boundaries of the Hawke's Bay region's air sheds gazetted as per (b) above, are shown in *Schedule XIV of the HB Regional Resource Management Plan.*

Fuel Poverty: - Households that need to spend 10% or more of [their]...(disposable) income on household energy, including heating the house to acceptable [World Health Organization] levels'

Greater region airshed: This is an airshed covering those parts of the region which have not been specifically gazetted by the Hawke's Bay Regional Council. It does not include the Hastings Airshed or the Napier Airshed.

Hastings airshed: means an airshed identified over the Hastings urban area and surrounds for the purposes of managing local ambient air quality; this area is identified in Plan Change 2 to the Hawke's Bay Regional Resource Management Plan.

Heat pump (inverter): means a heat transfer unit, but unlike conventional heaters, the power isn't converted into heat - it is only used to power the pump that circulates the liquid through the system. The same principle is at work in your refrigerator. Even on bitterly cold days, its heat exchanger unit can extract 'warmth' from cold air outside and transfer it into a heated room, just as your fridge keeps extracting heat from your freezer even when it's below zero.

Incinerator: A device that is capable of burning solid fuel and waste, but the combustion is not able to be controlled and is not totally enclosed.

Multifuel burner: An appliance designed to burn more than one type of solid fuel.

Napier airshed: means an airshed identified over the Napier urban area and surrounds for the purposes of managing local ambient air quality, this area is identified in Plan Change 2 to the Hawke's Bay Regional Resource Management Plan.

National Ambient Air Quality Standard: A standard specified under the Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins, and Other Toxics) Regulations 2004.

NESAQ: see National Ambient Air Quality Standard

NESAQ compliant burning appliance: A small scale solid fuel burning appliance that meets the standards in Plan Change 2's Schedule XII, and is specifically stated on the approved burner list which will be provided on request by the Hawke's Bay Regional Council.

Open fire: Includes any small-scale fuel burning device or construction installed in or attached to any building that is capable of burning solid fuel, but the combustion is not totally enclosed.

Outdoor burning: The combustion of any material in the open air, other than in purpose-built fuel burning equipment designed to control the combustion process. Outdoor burning includes the use of any fire, or bonfire or burning in drums and backyard rubbish incinerators, but excludes the burning of fuels in hangi and barbeques for food cooking purposes. *Note:* the NESAQ overrides any rules within the RRMP and prohibits the burning of certain materials in the open.

Particulates: Includes smoke, deposited particulates, suspended particulates, respirable particulates and visibility – reducing particulates. Particles range in size from 100 microns down to aggregations of molecules.

Pellet burner: Any small-scale solid fuel burning appliance that burns pellets of compressed wood sawdust, and where the pellets and air are mechanically delivered to an enclosed combustion chamber at a controlled rate. 'Pellet burner' and 'pellet fire' have the same meaning.

Plan Change: refers to Plan Change 2 to the Hawke's Bay Regional Resource Management Plan relating to air quality. For convenience, references in this document to Plan Change also refer to Variation 2 to the Proposed Hawke's Bay Regional Coastal Environment Plan for air quality.

PM₁₀: Particulate matter that is less than 10 microns in aerodynamic diameter (i.e. smoke).

RRMP: Hawke's Bay Regional Resource Management Plan

Small-scale fuel burning appliance: Any appliance which burns: solid fuel, diesel, oil or other liquid fuels for cooking, space or water heating or other purposes, where the net heat output from the combustion is not greater than 70 kilowatts (kW) for any gaseous or liquefied gaseous fuel, or not greater than 40 kW for any other fuel.

Small-scale solid fuel burning appliance: A combustion appliance, with a heat generation of up to 40 kilowatts (kW), in which solid fuel is burnt for heating or cooking, and is primarily used in residential dwellings. It includes (but is not limited to) appliances for interior space heating in buildings, such as wood burners, pellet burners, pot belly and domestic ranges and stoves, water heaters or central heating units, multi-fuel (coal and wood), and similar appliances, but excludes small-scale domestic devices for smoking food. A small-scale solid fuel burning appliance does not include any incinerator or open fire as defined in this glossary.

Solid fuel: A solid substance that releases useable energy when burnt (e.g. coal and wood).

Solid fuel burner: Cooking stoves, wetbacks, multifuel burners and woodburners.

Thermal efficiency: Ratio of useable heat energy output to energy input. The more efficient heating units will require less energy (electricity etc) to create heat.

Vegetative matter: Includes but is not limited to: stalks and stubble (stems); leaves; and seed pods; prunings; and wood.

Wrap Around Services: A coordinated system of support by organisations to meet the varied needs of a family

Wood burner: A domestic heating appliance that burns wood, but does not include:

- (a) An open fire
- (b) a multi-fuel heater, a pellet heater, or a coal burning heater
- (c) a stove that is designed and used for cooking and is heated by burning wood.

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Appendix 1 Literature Review

Review of Key Documents to Inform the Health Impact Assessment of Hawke's Bay Regional Council's Clean Heat Strategy

Prepared by Kate Marsh from Quigley and Watts

For

**Hawke's Bay District Health Board
&
Hawke's Bay Regional Council**

March 2009

Contact:

Quigley and Watts Ltd
ph (04) 472 0139
fax (04) 472 0144
office@quigleyandwatts.co.nz

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Executive Summary

Air quality is an issue that affects all New Zealanders. The Hawke's Bay Regional Council and the Hawke's Bay District Health Board funded this review of key documents to inform the health impact assessment on the Council's draft policy on solid fuel home heating appliances and outdoor burning within the Napier and Hastings airsheds. The Council is proposing these changes to comply with the National Environmental Standards for Air Quality (the standards).

- Under the standards, which were set by the Ministry for the Environment, unitary authorities and regional councils in New Zealand are required to ensure their regions PM₁₀ levels are below the average daily threshold of 50 micrograms per cubic metre by 2013.
- Like the rest of New Zealand, Hawke's Bay will only be allowed to exceed the threshold once a year after 2013 before they breach the standards. If that happens, the Council may face constraints on resource consents which will have implications for the local community.
- High PM₁₀ levels are an issue because PM₁₀ pollutes the air and causes adverse health outcomes.
- The main source of PM₁₀ is solid fuels in home heating appliances, particularly wood burners.
- In order to reduce PM₁₀ levels in Hawke's Bay, the Council proposed rule changes around the installation and operation of non-compliant open fires and wood burners.

This report presents the findings from a review of key documents explaining how the standards were set, how outdoor PM₁₀ levels impact health outcomes, how home heating appliances affect indoor air quality and health, and the financial impact of home heating appliances.

Setting the National Environmental Standards for Air Quality

- In the National Environmental Standards for Air Quality (2004), the Ministry for the Environment set New Zealand PM₁₀ levels on an average daily threshold.
- The reason behind enforcing an average daily threshold is that many regions exceed the threshold in winter and not in summer. This means those regions could have had PM₁₀ discharges below an average annual threshold but still have had some PM₁₀ discharges above an average daily threshold. Enforcing average annual emissions only would not identify such short-term exceedences.
- An average daily threshold relates to acute health effects rather than an average annual threshold which relates to chronic health effects.
- There is no known threshold below which PM₁₀ does not adversely impact upon health.
- From a health perspective, the standards have been set appropriately by the Ministry for the Environment.

Outdoor PM₁₀ and Health

- PM₁₀ is bad for health because it bypasses the nose and mouth and gets stuck in the lungs. This results in both minor and major adverse health outcomes ranging from nose and throat irritations to premature death.
- Short-term exposure tends to lead to acute effects while long-term exposure tends to lead to chronic effects.
- Research shows there is an increase in death rates when exposed to PM₁₀ in the short-term and an even greater increase in death rates when exposed to PM₁₀ in the long-term.

- While there have been few epidemiological studies undertaken in New Zealand, the results from one study in particular showed that the combined effect on daily mortality of up to 40 preceding days' exposure may be much greater than the single-day effect.
- There is little evidence on the proportion of Hawke's Bay death and hospitalisation rates that are attributable to air pollution. However, Fisher et al (2007) calculated that approximately 27 deaths and 55 hospital admissions in Napier and Hastings are estimated to be due to air pollution annually.
- While there are gaps in the research, national and international studies consistently found an association between PM₁₀ and adverse health outcomes

Home Heating Appliances and Indoor Air Quality and Health Outcomes

- Home heating appliances affect indoor air quality in relation to PM₁₀, temperature and moisture. This in turn affects health outcomes by causing and/or aggravating chronic conditions such as sneezing and coughing, cancer and respiratory disorders (which can also be acute eg, fatal asthma attack) to acute conditions such as fatal injuries.
- Indoor air quality is a concern in New Zealand because many homes are badly insulated, cold and damp, and often have lower indoor air temperatures than houses in other countries.
- Houses that are cold are more likely to be damp and mouldy, and this is exacerbated when home heating appliances that create moisture and condensation are used.
- Some research indicates that pollution levels inside the home are often similar to pollution levels outside the home due to PM₁₀ discharged from solid fuel home heating appliances.
- The risks to health are further compounded as indoor pollutants have as much as a 1000-fold greater chance of being inhaled than outdoor pollutants.
- There are currently no standards for indoor air quality in New Zealand. The National Environmental Standards for Air Quality (the standards) apply to outdoor air quality alone.

Financial Costs of Installing and Operating Home Heating Appliances

- The financial cost of improving indoor air quality in relation to PM₁₀, temperature and moisture is a major issue for many households in New Zealand.
- Many New Zealand households experience fuel poverty due to the increased cost of daily living, particularly low income households.
- The most cost effective appliances to operate are the most expensive appliances to install. Conversely, the cheapest appliances to install (ie, unflued gas heaters, electric fan heaters) are the most expensive to operate (in the long-term).
- Many households cannot afford the substantial upfront cost required and end up purchasing cheaper home heating appliances that cost more to operate, and are often detrimental to their health.
- Unflued gas heaters are a particular concern as they are relatively inexpensive to purchase, yet they are one of the most expensive home heating appliances to operate and they have known adverse health impacts.

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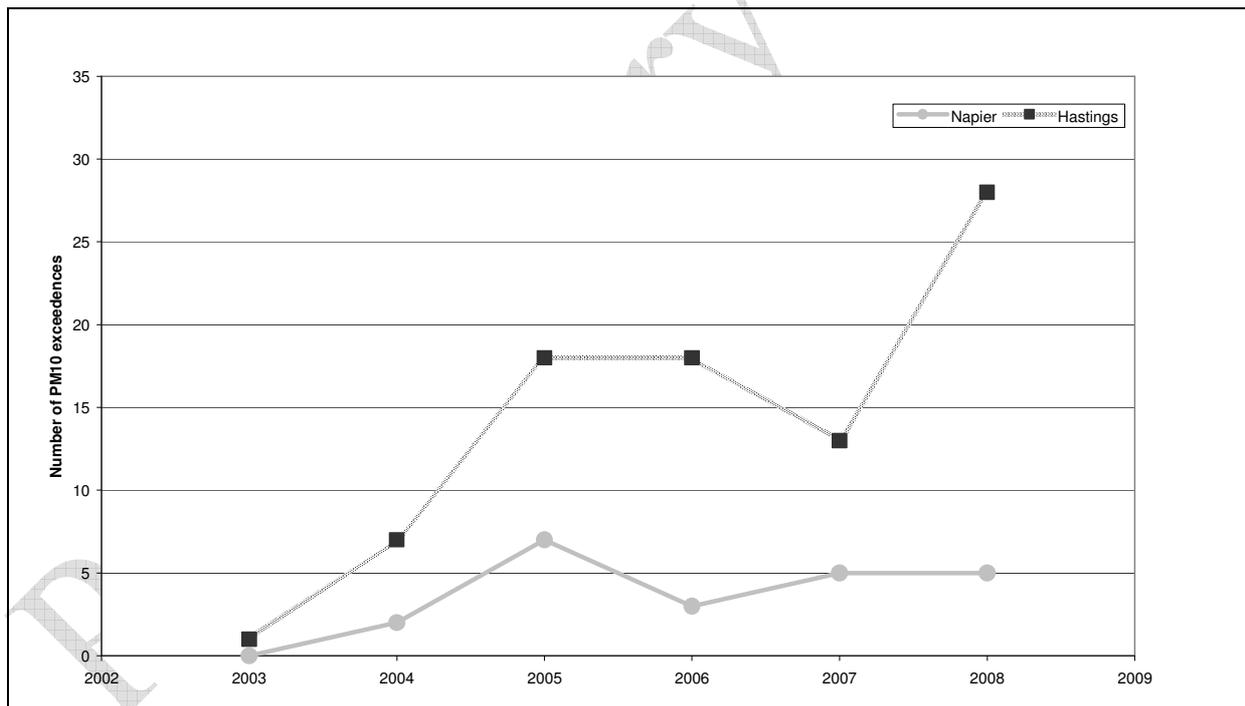
1. Introduction

Air is important for our health and wellbeing. It sustains us with every breath that we take. The quality of the air we breathe is therefore a matter of importance to all New Zealanders.

In 2004 it was the collective view of New Zealanders from business, local government and the wider community that New Zealand needed National Environmental Standards for Air Quality (the standards) (Ministry for the Environment, 2004). The standards were set on an average daily level of 50 µg/m³ (50 micrograms of PM₁₀ per cubic metre of air) and allowance was made until 2013 for regional councils throughout New Zealand to become compliant.

Within the Hawke's Bay Region, PM₁₀ levels have been monitored in Napier since 2000 and in Hastings since 2003. During this period, both areas have generally exceeded the standard of no more than one exceedence per area per year (Figure 1).

Figure 2: Annual PM₁₀ exceedences in Napier and Hastings



Source: Compiled from SOE reports⁶

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<http://www.hbrc.govt.nz/ReadAboutIt/StateofEnvironment/tabid/247/Default.aspx>, and
<http://www.hbrc.govt.nz/ReadAboutIt/StateofEnvironment/MonthlySOEReports/tabid/795/Default.aspx>

The Hawke's Bay Regional Council is currently developing a local approach to comply with the standards. In December 2008, a new policy was drafted on solid fuel heating appliances⁷ and outdoor burning within the Napier and Hastings airsheds. Key points from the proposed rule change relating to PM₁₀ levels are:

- from 2011, all open fires and wood burners installed before 31 December 1995 will be prohibited from use;
- from 2012, all wood burners installed before 31 August 2005 will be prohibited from use;
- from 2013, all wood burners that do not comply with the standards will be prohibited from use;
- all new and replacement wood burners in the Hastings Airshed must meet an emission rate of 0.7 grams of PM₁₀ for each kilogram of wood burned;⁸
- all new and replacement wood burners in the Napier Airshed must meet an emission rate of 1.5 grams of PM₁₀ for each kilogram of wood burned;
- at the point of selling a house, the wood burner must be upgraded if it does not meet the new emission standards⁹; and
- resource consent is required to undertake outdoor burning during May – August (inclusive).

(Hawke's Bay Regional Council, 2008)

The health impact assessment considers how the drafted rule change might impact either positively or negatively on the health and wellbeing of people in Hawke's Bay. It also aims to gather evidence about the proposed change, and make constructive recommendations about how the draft rules and any future programme may be improved. This review of key documents serves to inform the health impact assessment by describing how the standards were set, how outdoor PM₁₀ discharge affects health, and how different types of home heating appliances (including solid fuel heating appliances) affect the indoor environment and how that affects health.

1.1 Aims of the Literature Review

This literature review aims to identify:

- how the National Environmental Standards for Air Quality (the standards) have been set
- how outdoor PM₁₀ affect health outcomes
- how different types of home heating appliances affect indoor air quality in relation to PM₁₀, temperature and moisture, and how that affects health outcomes
- the financial cost of home heating appliances

1.2 Background

1.2.1 National Environmental Standards for Air Quality

New Zealand's air quality as a whole is not particularly bad. However, there are regions that have consistently high levels of PM₁₀ at certain times of the day and the year. The Ministry for

⁷ Solid fuel heating appliances refers to wood and coal heating appliances such as open fires, wood burners, and pellet fires (Fisher et al, 2007).

⁸ The Hawke's Bay Regional Council is currently proposing to change this rule.

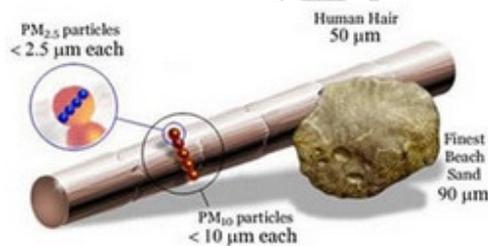
⁹ The Hawke's Bay Regional Council is currently proposing to change this rule.

the Environment is concerned these levels will get worse with the growing population and increasing size of urban areas. It is for these reasons that the standards have been introduced. All New Zealand Regional Councils are currently required to meet the standards by 2013. The standards apply as a regulation under the Resource Management Act (1991) and include five standards for outdoor air quality. Standards for small particles, known as PM₁₀, are one of the five air quality standards.

The standards allow one exceedence of the PM₁₀ threshold per year. The PM₁₀ threshold is 50 µg/m³ (micrograms per cubic meter) (Ministry for the Environment, 2005:22). If an airshed within a Regional Council goes above the daily average of 50 µg/m³ two or more times (including the one exceedence allowed) after 31 August 2013, then the Regional Council will not be able to grant resource consents to discharge PM₁₀ into that air shed. This is important because Council issues resource consents for air discharges to industrial and trade premises and it is this sector which will be predominantly affected by Council's inability to grant resource consents. The unintended consequences to the regional economy have not been measured. The standards are explained in further detail in Section One.

1.2.2 Explaining PM10

PM₁₀ is particulate matter that is less than 10 microns in aerodynamic diameter. Approximately five pieces of PM₁₀ side by side are the same width as a human hair (Ministry for the Environment, 2009).



Source: Ministry for the Environment,
<http://www.mfe.govt.nz/issues/air/breathe/particles.html>

Typically, the main source of PM₁₀ is solid fuels burnt for home heating. Other sources of PM₁₀ include vehicle exhaust emissions, industry, outdoor burning, soil/compost and sea spray. There are a number of factors that lead to poor air quality stemming from home heating appliances. These factors include:

- geographic factors such as population density and number and size of wood/coal burners in operation
- environmental factors such as climate, weather and topography
- infrastructure factors such as quality of housing ie, extent and efficiency of insulation at the property
- individual factors such as people's attitudes, knowledge, skills and awareness of good practice when using a solid-fuel burner ie, choice of fuel (soft or wet wood is more polluting than hard dry wood)

(Fisher et al, 2007:128).

While home heating appliances discharge similar amounts of contaminants to other burning processes such as industrial burning and discharge, there are several reasons for concern around the pollutants being caused by residential burning and discharge:

- when there are many small appliances located in the one area, the small discharges add up to a large discharge (there is a cumulative effect)
- many home heating appliances have a comparatively high discharge in proportion to their heat output or fuel consumption
- the low height of discharge, particularly with regard to potential nuisance effects on neighbours at ground level

(Millichamp and Wilton, 2002:2)

Limited laboratory testing indicates older home heating appliances such as open fireplaces and old non-compliant wood burners, discharge higher levels of particulates than new home heating appliances (Millichamp and Wilton, 2002:7).

The design, selection, installation and operation of solid fuel home heating appliances can contribute to indoor and outdoor air pollution. These aspects are somewhat interrelated and dependent on one another. 'Modern appliances are designed to ensure combustion of all gases and particles takes place within the firebox to maximise heat output and to minimise discharge of particulate emissions to the atmosphere' (New Zealand Home Heating Association, 2002:7). However, this relies on the person operating the fire eg. they must ensure the wood is dry because if the wood is wet, excess smoke can be produced both indoors and outdoors.

Prior to sale, wood burners are required to go through a certification process (meaning they must meet the New Zealand Standard NZS 7403 for discharge of particulate matter) before they can be installed in New Zealand homes. 'The certification process uses a method to evaluate the relative performance of wood burning appliances under specified burn rates and controlled conditions using standard timber sizing and loading conditions' (Millichamp and Wilton, 2002:6). However, in normal everyday use the actual emissions can be higher than the certification emission rates.

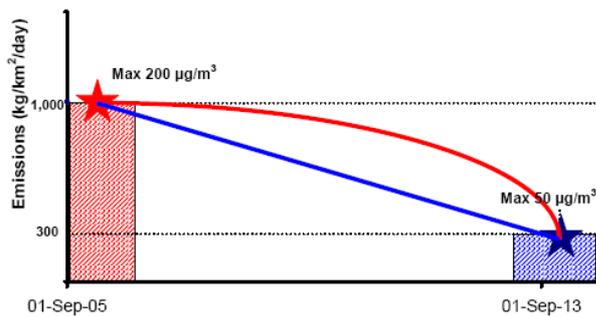
To measure the quantity of pollutants being produced, scientists in New Zealand, Europe and Australia generally measure the amount of discharge in relation to the amount of dry fuel burned (g discharge/kg dry fuel) (Millichamp and Wilton, 2002:5). This measure provides an equivalent numerical result to g/hr which measures the mass of emissions per unit of time of appliance operation and is generally used in the United States and Canada (ibid).

1.2.3 Consequence of Exceeding the PM10 Threshold

There is a difference between compliance with the regulations and breaching the standards. 'A council that publicly notifies an exceedance of the air quality concentration limits (breach) has fulfilled its monitoring and reporting requirements under the national environmental standards and is in compliance' (Ministry for the Environment, 2005:22). Thus, they have complied with the regulations but have still breached the standards.

An estimated projection of how councils will attain compliance by 2013 is shown in Figure 2.

Figure 3: Straight/curved line paths to compliance



(Source: Ministry for the Environment, 2005:25)

Up to 2013, if a council exceeds the standards, they will face constraints regarding resource consents for discharges of PM₁₀. Beyond 2013, resource consents will be declined if PM₁₀ emissions exceed the guidelines. This has implications for not just councils but the communities they serve. 'This would result in significant implications for the community in terms of loss of employment and local industry from the area because it is typically industrial activities that require resource consents for their air discharges' (Hawke's Bay Regional Council, 2008:2).

Table 1 below shows the factors that need to be taken into account when applications for resource consent are being decided.

Table 1: Resource consents for significant discharges of PM₁₀ under section 17

Concentration of PM ₁₀ in the airshed at the time the application is decided	Application for renewed discharges causing significant increase in concentration	Application for new discharges causing significant increase in concentration
Tracking below straight line path or curved line path	Can be granted if increase in PM ₁₀ offset by amount equivalent to increase above path	Can be granted if increase in PM ₁₀ offset by amount equivalent to increase above path
Tracking on straight line path or curved line path	Can be granted if increase in PM ₁₀ offset by amount equivalent to increase above path	Can be granted if increase in PM ₁₀ offset by amount equivalent to increase above path
Tracking above straight line path or curved line path	Can be granted only if discharges fully offset	Must be declined, no ability to offset

(Source: Ministry for the Environment, 2005:26)

The Ministry for the Environment acknowledges that fluctuation in compliance with the standards for PM₁₀ is often due to weather patterns. 'Yearly weather patterns will continue to be reflected in the PM₁₀ levels, and therefore we can expect to see further fluctuation in compliance in the future' (Ministry for the Environment, 2009).

1.2.3 New Zealand PM10 Levels

As mentioned above, New Zealand has 'relatively good air quality' but there are areas where PM₁₀ levels have been consistently above the 24 hour average daily threshold of 50 µg/m³. A range of methods have been used to measure PM₁₀ in various parts of the country, however even when that is allowed for, New Zealand levels still exceed internationally accepted levels (Millichamp and Wilton 2002:3).

It may come as a surprise to many people that solid fuel home heating appliances are one of the main causes of air pollution in New Zealand because of the public perception that industry and vehicles are the most significant contributors (Fisher et al, 2007). There are approximately 480,000 solid fuel home heating appliances installed in homes throughout New Zealand (Fisher et al, 2007:128). Based on regional inventories that have been done across the country, home heating appliances appears to contribute between 50 and 90% of total PM₁₀ emissions (Millichamp and Wilton, 2002:4). A study of the Hastings airshed found that over the course of a year, solid fuel heating appliances contributed 59% of annual PM₁₀ emissions (Wilton et al, 2007).

Wood Burners

Wood burners in particular are a popular heating appliance. 'Emissions inventory and modelling show that home heating with wood is the main source of ambient...[air pollution] in the winter (90%), May to August...During the rest of the year (eight months), motor vehicles and industries are the sources of almost all the air pollution' (Fisher et al, 2007:9).

There are approximately 11,000 wood burners within the Hastings airshed and 10,700 wood burners within the Napier airshed. During winter these household burners contribute to just under 90% of the PM₁₀ emissions (Hawke's Bay Regional Council, n.d.). This is why the standards focus on wood burners and it is also why the Hawke's Bay Regional Council are phasing out non-compliant wood burners and replacing them with compliant ones.

2. Methods

This review aimed to investigate how the National Environmental Standards for Air Quality were set. It also aimed to investigate what impact indoor and outdoor air pollution has on health, as well as the financial costs of heating appliances. The research questions for this literature review were:

- How have the National Environmental Standards for Air Quality been set?
- How does outdoor PM₁₀ affect health outcomes?
- How do different types of home heating appliances affect indoor air quality (PM₁₀, temperature and moisture) and how do they affect health outcomes?
- What are the financial costs of installing and operating home heating appliances?

2.1 Search Strategy

Due to the large amount of literature (strategies, reports, papers) on air pollution and PM₁₀ on the Ministry for the Environment's webpage, it was not necessary to undertake a separate search of databases. Thus, this review of key documents draws heavily on work undertaken by the Ministry for the Environment and other key websites (see below for the list of websites). It also drew heavily on a key New Zealand report by Fisher et al (2007) *Health and Air Pollution in New Zealand: Main Report* which identified and quantified New Zealanders health risks that were due to air pollution. Reference lists from major articles were scanned and key people were contacted directly (see list below). Where possible, New Zealand and Hawke's Bay specific information was sought and included. Both quantitative and qualitative evidence was included in the review.

Sources:

Websites searched:

- Ministry for the Environment (Ministry for the Environment) - <http://www.mfe.govt.nz/>
- Housing and Health He Kainga Oranga Centre at Otago School of Medicine - [http://www.uow.otago.ac.nz/academic/dph/research/housing/Housing%20and%20\(Dis\)ability%20study.html](http://www.uow.otago.ac.nz/academic/dph/research/housing/Housing%20and%20(Dis)ability%20study.html)
- Centre for Housing Research Aotearoa New Zealand (CHRANZ) - <http://www.chranz.co.nz/>
- Housing New Zealand - <http://www.hnzc.co.nz/hnzc/web/home.htm>
- Department of Building and Housing - <http://www.dbh.govt.nz/>
- World Health Organization - <http://www.who.int/en/>
- Hawke's Bay Regional Council - <http://www.hbrc.govt.nz/>

Key people contacted:

- Louise Wickham at Ministry for the Environment provided clarification on air pollution strategies as well as links to other useful strategies - phone (04) 439 7475 or email louise.wickham@mfe.govt.nz
- Philippa Howden-Chapman provided papers on housing and health – email Philippa.howden-chapman@otago.ac.nz
- Belinda Riley at the Hawke's Bay Regional Council provided information on air pollution in Hawke's Bay – email Belinda@hbrc.govt.nz

- Caroline McElnay at the Hawke's Bay District Health Board provided estimates on how the health of people living in Hawke's Bay is affected by air pollution – email Caroline.McElnay@Hawke'sbaydhb.govt.nz

Preliminary Report

3. Findings

3.1 The National Environmental Standards for Air Quality

This section sets out the policy context for PM₁₀ levels in New Zealand. The purpose of this section is to describe the standards in more detail particularly in relation to how they were set, how they were developed, how they will be implemented, and how New Zealand's PM₁₀ standards compare to other countries PM₁₀ standards. Of particular interest is how the PM₁₀ threshold was set. The findings from this section will contribute to the Hawke's Bay Regional Council's body of knowledge about air pollution as they make plans to comply with the standards.

As described earlier, the standards were introduced in September 2004 to reduce average 24 hour PM₁₀ levels in New Zealand to under 50 µg/m³. Motivations for developing policies aimed at reducing PM₁₀ emissions have been due to the negative environmental effects as well as health effects. The Ministry for the Environment states:

The National Environmental Standards are national regulations designed to protect public health by setting 'bottom-line' values. The National Environmental Standards for Air Quality are the first suite of standards and include a design standard for wood burners in urban areas.

(Ministry for the Environment, n.d.a)

The standards are part of New Zealand's air pollution regulatory framework. The PM₁₀ levels set out in the framework were based on recommendations from the World Health Organization. The New Zealand air pollution regulatory framework contains the following air quality criteria:

- National Environmental Standards for Air Quality (2004)
- National Ambient Air Quality Guidelines (2002)
- Objectives and policies in councils regional plans¹⁰ – these are statutory requirements under the Resource Management Act

The standards were set by the Ministry for the Environment and are the responsibility of parties with responsibilities under the Resource Management Act (1991) to implement. The Resource Management Act is the main legislation governing air quality in New Zealand and the National Environmental Standards for Air Quality are linked to sections 43 and 44 of the Act. '*Any council that does not undertake the requirements outlined in the regulations, or fails to enforce the regulations, is failing to meet its responsibilities under the [Resource Management Act]*' (Ministry for the Environment, 2005:31). Regional councils and territorial authorities need to develop mitigation policies/procedures at the local level so their regions PM₁₀ levels are below those required by the standards by 2013.

The National Environmental Standards for Air Quality sets out guidelines relating to 14 standards:

- Five ambient air quality standards for carbon monoxide (CO), particles (PM₁₀), nitrogen dioxide (NO₂), sulphur dioxide (SO₂) and ozone (O₃)

¹⁰ If the air quality objectives in a regional plan are more stringent than the national environmental standards for air quality, then the regional plan takes precedence.

- A design standard for small-scale, domestic wood-burning appliances
- Seven activity standards prohibiting various activities that discharge unacceptable quantities of pollutants into the air (unless they gain resource consents)
- A design standard for the collection and destruction of landfill gas at large landfills

(Ministry for the Environment, 2005; Ministry for the Environment, 2004).

The first two are relevant to this literature review and are outlined in more detail below.

3.1.1 Ambient Air Quality Standards (relevant to PM10)

- The ambient standards are the minimum requirements that outdoor air quality should meet in order to guarantee a set level of protection for human health and the environment
- The standards require an ambient air quality concentration limit of 50 µg/m³ for PM₁₀ as a 24-hour average. The standard allows for one exceedence but must be met every day of the year.
- The standards do not apply in areas not in the open air ie, in a house and do not apply to sites to which resource consents apply, because such industrial sites are covered by Health and Safety Regulations.

(Ministry for the Environment, 2005:14-17)

3.1.2 Emission Standards for Wood Burners

- The standard specifies a maximum particle emission limit of 1.5 g/kg of wood burnt and specifies a test procedure for determining the rate of PM₁₀ emission from batch feed solid fuel home heating appliances
- From 1 September 2005 the New Zealand design standard for wood burners applies to all units installed on properties less than 2 hectares in lot size (it does not apply to existing wood burners unless they are re-installed)
- Older existing non-compliant wood burners need to be replaced with new ones that meet the proposed emission limit 15 years following installation
- The standard applies only to wood burners (it does not apply to open fires, multi fuel burners eg, coal, cooking stoves or pellet burners)
- The standard does not ban wetbacks; it sets a minimum requirement for thermal efficiency
- Recommended appliances include heat pumps, pellet burners, flued gas heaters, and low emission wood burners (in some locations)

(Ministry for the Environment, n.d.a; Ministry for the Environment, 2005; Ministry for the Environment, 2004)

3.1.3 The Process of Developing the National Environmental Standards for Air Quality

An involved process over a period of time has been used to develop the standards. A key part of that development was consultation with the public and local council.

2002:

- Series of public meetings held

2003:

- the Ministry for the Environment presented the concept of national environmental standards to regional council and unitary authority representatives
- the Government agreed that “the Minister for the Environment undertake an extensive public consultation process on a range of proposed standards, including air quality standards”
- the Ministry for the Environment hosted a national roadshow to obtain input from the community and key interest groups

2004:

- the Ministry for the Environment published a summary of submissions on the proposed standards. Extensive consultation was undertaken with local and central government and amendments were made.
- Ministry for the Environment published a cost benefit analysis of the proposed standards in accordance with section 32 of the RMA. The report concluded that standards present the most appropriate, effective and efficient means of meeting the Minister for the Environment’s objectives for air quality management.
- Cabinet approved the proposed policy of the national environmental standards. The Ministry for the Environment prepared drafting instructions which were forwarded to Parliamentary Counsel in August 2004
- the regulations were gazetted
- first of the standards took effect

2005:

- Ministry visited every regional council to discuss implementation of the standards
- Agreement on technical amendments to the standards from council and Government. Technical amendments gazetted.

(Ministry for the Environment, 2005:2-3)

3.1.4 Implementing the National Environmental Standards for Air Quality (relevant to PM10)

2005: regional councils and unitary authorities **must**:

- monitor air quality, if it is likely that the standard concentrations will be exceeded in an airshed, in accordance with the methods specified in the regulations
- give public notice if the standard concentrations are exceeded in an airshed (see section 3.5)
- ascertain ‘straight line’ requirements for consent processing for fine particle emissions in airsheds where the standard is exceeded and only grant new resource consents in line with the requirements outlined in regulations 17 to 21 (see section 3.6)
- enforce the wood burner design standard (see chapter 4)

2006 onwards:

- Councils are ‘invited’ to develop an ‘airshed action plan’ (this is not a legal requirement of the regulations) in order to move towards compliance with the standards by 2013 (this is a legal requirement of the regulations) (Ministry for the Environment, 2005:32)

2013:

- No more than one exceedence per year of the PM10 level of 50 µg/m³ per day (Ministry for the Environment, 2005:3-4)

3.1.5 Setting the Average 24 Hour PM10 Threshold of 50 µg/m³

Threshold levels at the population level are difficult to set because of individual factors eg, an individual may be more susceptible to death or disease at one point in their life than at another point. The Ministry for the Environment set the average daily threshold in conjunction with the World Health Organization's Air Quality Guidelines, which have been used by many developed countries to set national or local guidelines for maximum PM₁₀ emissions (Fisher et al, 2007:6). The World Health Organization 'take...short-term and long-term differences into account and recommend lower values for annual averages than the 24-hour averages' (Fisher et al, 2007:30). There is no annual average PM₁₀ threshold set out in the standards. The PM₁₀ concentration limit set out in the standards is consistent with several international standards, including the Australian national environmental protection measures and the European Union standards. However, the frequency of breaches of the standard (no more than one per year) is more stringent in New Zealand than in Australia (5 days per year at 50 µg/m³/24 hour period) and the European Union (35 days per year at 50 µg/m³/24 hour period). The USA standard is set at 1 day per year, but with a higher limit at 150 µg/m³/24 hour period.

'The threshold level...along with the dose-response relationship and the distribution of exposure, can be used to estimate the public health impact of air pollution' (Fisher et al, 2007:25). The threshold in the standards has been set on daily average PM₁₀ exposure which relates to acute health effects rather than annual average PM₁₀ exposure which relates to chronic health effects. It is important to note there is no known threshold below which PM₁₀ does not adversely impact upon health. The health effects from acute and chronic exposure to PM₁₀ are described in the next section.

3.1.6 Measuring and Monitoring PM10

New Zealand has been divided up into 'airsheds' which are regions or areas within which air pollution is measured. *'An airshed is a volume of air, bounded by geographical and/or meteorological constraints, within which activities discharge contaminants'* (Ministry for the Environment, 2002:28). Airsheds vary in size and may have 'hotspots' within them where pollution levels are elevated due to an industrial site for example.

Pollution levels within an air shed are influenced by complex interactions between the pollution sources, contaminants discharged into the air, meteorology, and topography. Information about all of these is required to understand the factors affecting pollution levels in an air shed, how they change over time and space, and the adverse effects they are having on people and the environment.
(Ministry for the Environment, 2002:28)

Continuous high volume sampling is needed in order to calculate a daily 24-hour mean which is what the standards are based on. 'This is necessary to properly assess compliance with the fine particle standard (50 µg/m³ not to be exceeded more than one 24-hour period in a 12-month period). Consequently, 'one day in three' or 'one day in two' monitoring is not sufficient for measuring ambient fine particles for the purposes of the standard' (Ministry for the Environment, 2005:21). Measuring one day in two or three does not provide an accurate measure of PM₁₀ levels as days are missed and the PM₁₀ levels on those days could have been above the threshold. The reason behind enforcing a 24-hour average is that many places exceed the standards in winter and not in summer. This means they could be below the annual threshold of 20 µg/m³ per year but have been above the daily threshold of 50 µg/m³ a number of times throughout the year. Enforcing average annual emissions alone would not identify such daily exceedences.

There has been an increase in PM₁₀ monitoring and a variety of continuous monitoring methods are now being used throughout the country (Wickham, 2009). 'The Ministry now has partnership agreements with all regional councils for monitoring fine particle pollution' (Ministry for the Environment, 2004:5).

3.1.7 Do the Benefits of the Standards Outweigh the Costs?

Whether the benefits of implementing the standards outweigh the costs of not implementing them is a complex question and many factors need to be considered. This is not just an economic issue but a physical, social and perhaps psychological one too. In an analysis of the costs and benefits of the proposed standards (2004a), the Ministry for the Environment concluded the proposed standards were '*extremely cost-effective*' economically in comparison to the premature mortality that would result from PM₁₀ exposure if they were not put in place (Ministry for the Environment, 2004:45). The Ministry said 'the level of costs would need to be substantially higher compared to the level of avoided premature mortality for the standard not to be economically justified' (Ministry for the Environment, 2004:46). '*Costs associated with home heating*' was an area the Ministry said needed more detailed research (2004a:43).

According to Liz Lambert at the Hawke's Bay Regional Council, the cost of implementation will be greater than what the Ministry for the Environment estimated. The Ministry estimated the cost of implementation would be around \$120 million for the whole country. However, in Hawke's Bay alone the cost of implementation is estimated to be around \$90 million (Lambert, 2009).

Section 5.5.1 of the s.32 identified the four affected sectors as central government, local government, industry and households but omitted to factor in the total costs to the household sector, as the cost-benefit analysis factored in just \$500 per household (Lambert, 2009).

3.2 Outdoor PM10 and Health Outcomes

In line with the standards, the Hawke's Bay Regional Council's plan change proposes to phase out non-compliant wood burners to reduce outdoor PM₁₀ levels in the Napier and Hastings airsheds. This is to reduce the environmental impacts of PM₁₀ as well as the adverse health affects. This section investigates how outdoor PM₁₀ affects health outcomes.

3.2.1 The Health Effects of PM10

Estimating the health effects caused by air pollution is complex because air pollution is highly variable in time and space and is affected by:

- the weather
- what is being emitted through various activities
- location-specific features eg, valleys and where people live and work in relation to the sources

(Fisher et al, 2007:S5)

While recent studies have shown PM_{2.5} is generally a better predictor of health effects than PM₁₀, and that it is probably the finer particles that cause the greater health effects, most studies have measured the health effects of PM₁₀. Findings from those studies indicate there is a causal effect between exposure to PM₁₀ and adverse health effects (Environet Limited, 2003b;

Fisher et al, 2007; Millichamp and Wilton, 2002). PM₁₀ causes adverse health effects because of its size; unlike larger particles that get caught in the nose and mouth, PM₁₀ are so small they bypass the nose and mouth and get stuck in the lungs (Environet Limited, 2003b). While the exact biological mechanism(s) through which PM₁₀ affects health outcomes remains unknown, research shows there is an increase in death rates when exposed to PM₁₀ in the short-term and an even greater increase in death rates when exposed to PM₁₀ in the long-term.

There are a number of different health effects resulting from exposure to PM₁₀ which range from minor outcomes to more serious outcomes. Research shows that PM₁₀ affect or cause the following adverse health outcomes:

- Minor nose and throat irritations
- Coughs
- Asthma
- Bronchitis
- Restricted activity days
- Respiratory illness
- Aggravation of existing respiratory and cardiovascular disease
- Emphysema
- Chronic airways obstruction
- Extrinsic allergic alveolitis
- Cardiac illness
- Premature death

(Environet Limited, 2003b; Fisher et al, 2007)

These health outcomes result in increased doctors' visits and hospital admissions. Research indicates that some groups in the population are more at risk than others. These groups include young children and infants, the elderly, people with existing respiratory and cardiovascular conditions/diseases, asthmatics and people from lower socioeconomic groups (Fisher et al, 2007). The health effects seem to fall disproportionately on these most at risks groups.

The health outcomes of exposure to PM₁₀ depends largely on the type of exposure ie, short-term (generally 1 day) or long-term exposure (generally 1 year or longer). Short-term exposure tends to lead to acute affects while long-term exposure tends to lead to chronic effects (Fisher et al, 2007).

3.2.3 Short-term Exposure to PM10

Most of the studies on exposure to PM₁₀ are short-term studies that show the acute effects. Short-term can be described as same day air pollution or two day air pollution. Research shows there is an association between short-term exposure to PM₁₀ and adverse health effects even in countries that have low PM₁₀ levels (Fisher et al, 2007). '*The short-term mortality increase in relation to daily levels of particulate matter (PM₁₀ or PM_{2.5}) is approximately 0.5-1% increase per 10 µg/m³ PM₁₀ increase*' (Fisher et al, 2007:S1).

Most of the studies on health effects due to short-term exposure to PM₁₀ have been time-series studies. '*Time-series studies describe the short-term relationship between air pollution and mortality (and/or morbidity) by comparing daily mortality or daily cases of morbidity (usually hospital admissions) with daily air pollutant levels*' (Fisher et al, 2007:15). Daily time-series studies can only show the short-term relationship, capturing a 'snapshot' in time rather than

following people over a longer period. The weakness with this kind of study is that causation can be difficult to prove ie, was the health effect actually due to exposure to PM₁₀ or to something else? In focusing on measuring the effect in the short-term, time-series studies are more likely to pick up acute cases rather than chronic conditions.

[Time series methodology] associates only those deaths that occur a relatively short time after the pollution episode to PM₁₀ concentrations. Thus they are limited to a selection of the acute impacts but do not estimate the reduced life expectancy due to long-term morbidity enhanced by air pollution (Environet Limited, 2003b:11).

Short-term measures of PM₁₀ exposure on health do not measure cumulative effects as they generally measure exposure using one or two day moving averages. Research on the cumulative exposure of air pollution indicates that the effects of air pollution last longer than just a few days (Fisher et al, 2007). *'The higher relative risk associated with cumulative exposure to PM₁₀ compared to the results using one or two days moving averages of PM₁₀ showed that the time-series studies using a single-day exposure level underestimate the real risk of PM₁₀'* (Fisher et al, 2007:17). These studies are still useful though because most of them show an association between PM₁₀ exposure and adverse health outcomes (Fisher et al, 2007).

3.2.4 Long-term Exposure to PM10

Fewer studies have been undertaken on long-term exposure to PM₁₀ than short-term exposure, so less is known about chronic health effects. Nonetheless, research shows there is a cumulative effect in exposure to PM₁₀ which leads to greater health impacts (Fisher et al, 2007). Those health impacts include increased rates of bronchitis and reduced lung function as well as a greater increase of mortality.

The resulting long-term mortality increase associated with long-term exposure is substantially higher than the short-term increase. Recent advanced statistical analysis indicates that the mortality increase per 10 µg/m³ PM₁₀ may be as high as 5-10% (Fisher et al, 2007:S1).

Fisher et al (2007) estimate this to be 901 cases of increased premature mortality per year in New Zealand (p.96).

Ecological and prospective cohort studies have been used to measure the long-term effects of air pollution on health. While ecological studies found higher morbidity/mortality rates in areas with higher air pollution, these studies were at the population level and could not control for individual characteristics or confounders (Fisher et al, 2007). Prospective cohort studies on the other hand, could control for those confounding factors, however few of them have been completed due to budget and time restraints. Nonetheless, results from the completed cohort studies clearly show an association between particulates and ill health. The prospective cohort study is the strongest method to use because the causal pathway is clear and people are followed over time so causality can be established ie, that exposure to PM₁₀ earlier in time leads to adverse health effects at a later date.

3.2.5 The Health of New Zealanders in Relation to PM10

Despite the vast number of studies undertaken in other developed countries, there have been few epidemiological studies undertaken in New Zealand that measure the effects of PM₁₀ exposure on health. Most of what has been done has been undertaken in Christchurch and

most of the studies were time-series so could only estimate the short-term mortality and morbidity effects of New Zealanders exposed to PM₁₀.

The short-term studies (Fisher et al, 2002; Hales et al, 2000; McGowan et al, 2002) found an association between 24-hour concentrations of PM₁₀ and death rates (one day lag) and hospital admissions. Hales et al (2000) found that a 10 µg/m³ increase in 24-hour PM₁₀ was associated with a 1% increase in deaths from all causes and a 4% increase in deaths from respiratory conditions. McGowan et al (2002) found a 3% increase in respiratory hospital admissions of adults and children and a 1% increase in cardiac hospital admissions of adults. In addition, a study commissioned by Ministry of Transport into the health impacts of PM₁₀ emissions from vehicles calculated that 399 people over 30 years of age were likely to die earlier each year due to exposure to PM₁₀ emissions from vehicles than they would have if they were not exposed to PM₁₀ emissions from vehicles (Fisher et al, 2002).

The HAPiNZ (Health and Air Pollution in New Zealand) study (2007) adds evidence to the long-term health effects of exposure to PM₁₀ as it analysed existing and additional data over a 12 year period using reported 24-hour PM₁₀ levels. The results from a fine scale analysis in Auckland and Christchurch showed higher risks than the short-term time-series studies had showed (ibid). HAPiNZ found that in Christchurch, *'the distributed lag analysis showed that the combined effect on daily mortality of up to 40 preceding days' exposure may be much greater (on average 13-23% increase in mortality per 10 µg/m³ increase of PM₁₀) than the single-day effect'* (Fisher et al, 2007:58).

Table 2 summarises the health effects¹¹ for the 67 urban areas studied in the HAPiNZ (Health and Air Pollution in New Zealand) study (2007). The health effects are broken into health effects from domestic sources, vehicle and industrial.

Table 2: Effects of air pollution in New Zealand, by source and effect, 2001 (number of cases for the population over 30 years old)

Effect	Domestic	Vehicle	Industrial	Total
Mortality (for PM ₁₀ , NO ₂)	356	414	131	901
Mortality (for CO)	70	86	22	178
Bronchitis and related	887	541	116	1,544
Acute respiratory admissions	267	163	35	465
Acute cardiac admissions	137	83	18	238
Cancer	19	22	6	47
Restricted-activity days	1,105,000	671,000	145,000	1,921,000

Source: Fisher et al, 2007:S7

The table shows that air pollution is associated with:

¹¹ The bulk of these effects are associated with particulate pollution (PM₁₀), but there are also effects associated with other pollutants, such as NO₂, CO and volatile organic compounds.

- 1,079 cases of premature mortality – that is, people dying earlier than they would have if they had not been exposed to air pollution, mostly associated with PM₁₀ (901), but also with carbon monoxide (178)
- 1,544 extra cases of bronchitis and related illnesses
- 703 extra hospital admissions for respiratory (465) and cardiac illnesses (238)
- 1,921,000 restricted-activity days – that is, days on which people cannot do the things they might otherwise have done if air pollution was not present.

(Fisher et al, 2007:S7)

The findings from the few New Zealand studies are consistent with overseas studies.

3.2.6 The Health of People Living in Hawke's Bay in Relation to PM10

There is little to no evidence on the proportion of Hawke's Bay mortality and hospitalisation rates that are attributable to PM₁₀ exposure. Using Fisher et al's (2007) estimates for deaths and hospital admissions due to air pollution, Caroline McElnay from Hawke's Bay District Health Board calculated what those figures meant in terms of the percentage of deaths in the region due to exposure to air pollution.

- A total of 26.9 deaths in Napier and Hastings are estimated to be due to air pollution annually (Fisher et al, 2007). The actual number of deaths in 2001 in Napier and Hastings was 1063 so 2.5% of these are estimated to be due to air pollution (McElnay, 2009).
- [There are an estimated] 55 hospital admissions annually in Napier and Hastings due to chronic obstructive pulmonary disease [COPD] and other respiratory admissions (Fisher et al, 2007). The annual number of admissions for Hawke's Bay for COPD and other respiratory diseases in 2006/7 was 2661. Given that Napier and Hastings make up 85% of the Hawke's Bay population, one could expect 2262 admissions from Napier / Hastings of which 2.4% would be due to air pollution (McElnay, 2009).

However, McElnay warns:

These estimates were calculated assuming an average PM₁₀ level in both cities of 10.3 µg/m³. These estimates for PM₁₀ for both cities may therefore be inaccurate. Given...[additional] time one could estimate the health effects using actual PM₁₀ levels as measured in both cities' (McElnay, 2009).

3.2.7 Evidence Gaps/Limitations

Although there have been many studies undertaken on how PM₁₀ affects health, there is still a paucity of evidence in this area. Further research is needed to:

- ascertain how air pollution affects mortality and morbidity – we know it does but do not really know why it does (Fisher et al, 2007)
- show whether different particle sizes cause different health outcomes eg. PM_{2.5} being responsible for mortality and PM₁₀ being responsible for respiratory problems (Denlson et al, 2000)
- ascertain whether there is a threshold concentration of either PM₁₀ or PM_{2.5} below which adverse health outcomes will not be observed, though at the moment there is no known

safe lower limit (Denison et al, 2000; Environet Limited, 2003b; Millichamp and Wilton, 2002)

- ascertain whether PM₁₀ air pollution from different sources causes different levels of health risk ie, exposure to PM₁₀ from vehicles are worse for health than exposure to PM₁₀ from wood smoke. 'The time-series analysis indicates that there may be different relationships for wood smoke and vehicle emissions, but the results are by no means conclusive and international reviews consider all sources of PM₁₀ of equal importance' (Fisher et al, 2007:68)
- find out whether the contribution of PM₁₀ from sea spray need to be taken into consideration in certain beachside suburbs such as Sumner in Christchurch (Environet Limited, 2003b)
- ascertain how the health of people in different regions of New Zealand are affected by exposure to PM₁₀.

While there are gaps in the research, national and international studies consistently found an association between PM₁₀ and adverse health outcomes. Fisher et al conclude, '*while some health effects are known, others are not, and the state of knowledge is still developing rapidly*' (Fisher et al, 2007:S6).

3.3 Home Heating Sources and Indoor Air Quality and Health

The Hawke's Bay Regional Council's proposed rule change relates (mainly) to regulations surrounding solid fuel home heating appliances, particularly wood burners. The Council's aim is to phase out non-compliant wood burners and replace them with wood burners that comply with the standards in order to reduce the PM₁₀ levels in Hawke's Bay. Because the timeframe for compliance is now short, people living in Napier and Hastings will be forced into renewing non-compliant solid fuel home heating appliances quickly. A potential situation is that instead of replacing the non-compliant solid fuel home heating appliances, people may go without home heating or use home heating appliances that are detrimental to their health. Thus, people may be at greater risk of adverse health effects due to inadequate heating rather than through exposure to PM₁₀.

This section attempts to put some of this in perspective by investigating how home heating appliances affect indoor air quality (in relation to PM₁₀, temperature and moisture) and how that indoor air quality affects health. The financial costs of home heating appliances, including solid fuel home heating appliances, are also explored.

3.3.1 Indoor Air Quality and Health

While research into housing and health has had some exposure through the work of Philippa Howden-Chapman and colleagues at the Wellington School of Medicine, University of Otago, there is relatively little known in this area.

Despite the fact that we spend about three-quarters of our lives inside, we still know surprisingly little about the specific health effects of the indoor environment...the indoor environment has received much less attention than the outdoor environment. Yet the indoor environment has consistently higher concentrations of pollutants than the outdoor environment and some types of indoor heating can increase indoor air pollution.

(Howden-Chapman et al, 2006:2).

Research indicates home heating appliances affect indoor air quality and that in turn, affects people's health. There are a number of adverse health outcomes due to unhealthy indoor environments because many physiological stresses are placed on the body when it is cold and damp. PM₁₀, temperature and moisture cause and/or aggravate chronic conditions such as sneezing and coughing, respiratory disorders and cancer (which can be acute eg, fatal asthma attack) to acute conditions such as fatal injuries (World Health Organization, 2009a).

The World Health Organization says health effects can be directly triggered by the following inadequate housing conditions:

- mould growth
- indoor air pollution
- chemical emissions from building materials
- infestations - rats, pests
- inefficient heating systems and insulation
- lack of hygiene and sanitation amenities

(World Health Organization, 2009b)

Thus, housing is a major determinant of health. Regardless of the large proportion of time New Zealanders spend in their homes and the poor condition of many of their houses, there are no standards for indoor air quality (aside from standards for occupational indoor air) in New Zealand. The National Environmental Standards for Air Quality (the standards) apply to outdoor air quality alone.

Occupant behaviour is a contributing factor to poor indoor air quality.

Some significant factors are difficult to influence as they relate mainly to occupant behaviour, how they "use" the building and its immediate environment, factors including window openings, door openings, cooking habits, use of extract fans, bathing habits, all influence indoor air quality, dampness and mouldiness and can either support or work against ventilation systems, heating systems and the insulation construct of the building fabric.

(World Health Organization, 2004:21).

3.3.2 Home Heating Appliances and Indoor PM10 and Health

Open fires, wood burners, pellet fires, and unflued gas heaters all have the potential to emit PM₁₀ inside because PM₁₀ is created when fuel burns. Electrical home heating appliances do not affect indoor PM₁₀ levels. The amount of PM₁₀ discharged from the home heating appliances depends on the design, installation, operation, and maintenance of the appliance. The incorrect and/or inefficient use of solid fuel appliances and increased indoor (and outdoor) smoke was outlined in Section 1.2.2. Although, not much research was found on indoor PM₁₀ levels, Fisher et al said a small-scale project '*demonstrated that there was little difference between indoor and outdoor air pollution levels, except that houses with open fires had higher indoor levels of PM₁₀ than the outdoor levels...due to smoke from the fireplace*' (Fisher et al, 2007:48). The New

Zealand Home Heating Association commented that *'Health risks associated with particulates and toxic air pollutants are accentuated if smoke from solid fuel appliances leaks into living areas. The smell of smoke indoors is an indication of serious indoor air pollution'* (New Zealand Home Heating Association, 2002:6).

The extent to which outdoor-source particles affect a building's indoor air depends on:

- the houses location
- it's proximity to pollution sources (eg, is it near industry?)
- type of ventilation system
- the proportion of outdoor air in the indoor air mixture
- the location of air intakes

(European Federation of Allergies and Airways Diseases, 2003:34)

The health effects related to outdoor PM₁₀ exposure were documented in Section Two. While the health effects of indoor PM₁₀ exposure appear to be the same - premature mortality, aggravation of respiratory and cardiovascular disease, changes in lung function and increased respiratory symptoms, changes to lung tissues and structure, and altered respiratory defence mechanisms (European Federation of Allergies and Airways Diseases, 2004:34) - indoor pollutants have a greater chance of being inhaled than outdoor pollutants, particularly through smoke from solid fuel. Howden-Chapman found that, *'Pollutants emitted indoors have about a 1000-fold greater chance of being inhaled than those emitted from proximate outdoor sources'* (Howden-Chapman et al, 2008:2). Those spending more time in their homes are at risk of being more exposed to PM10 and their health being adversely affected. The elderly, babies and children are vulnerable groups.

In the [World Health Organization] European Region, 10 000 children aged 0–4 years are estimated to die each year from households' use of solid fuel, 90% of them in low- and middle-income countries. Owing to money or energy constraints, people burn waste or wood in rudimentary or badly maintained fireplaces for heating and cooking, instead of using cleaner but more expensive fuels.

(World Health Organization, 2009a)

It is important to note that other indoor pollutants affect health, particularly nitrogen dioxide which is produced as a by-product of burning fuel. *'Nitrogen dioxide is a proinflammatory gas and can exacerbate respiratory symptoms such as wheeze or cough. It can reduce immunity to lung infections and increase the severity and duration of an episode of flu'* (Howden-Chapman et al, 2008:2). Rooms with unflued gas heaters have been found to have higher concentrations of nitrogen dioxide than rooms with electric or flued heaters (Howden-Chapman et al, 2008:2). Kingham states, *'the biggest indicator of poor [indoor] air quality indoors is whether you've got an unflued gas heater or gas cooker'*. According to Kingham (n.d.), exposure to emissions from unflued gas heaters poses more of a health risk than exposure to emissions from vehicles.

3.3.3 Home Heating Appliances and Indoor Temperature and Health

New Zealand is known to have badly insulated homes with lower indoor air temperatures than other countries, particularly in bungalows and villas. *'An adequate heating regime by international standards is generally considered to be a temperature of 21C in the living areas and 18C elsewhere, with heat being available for 9h on weekdays and 16h at the weekends'* (Howden-Chapman et al, 2009:4). An issue in New Zealand is that New Zealanders often 'spot

heat' one room rather than the whole house resulting in a lower over air temperature. *'High humidity, poor insulation, poor maintenance practices, relatively low levels of heating, and a tendency for some newer, low cost homes to be very airtight mean that many New Zealand households live in damp and cold conditions'* (Howden-Chapman et al, n.d:2). While one could assume indoor temperature must be increasing with advances in home heating technologies, evidence suggests indoor temperatures in the North Island were 1 °C warmer in the 1970s compared to 2000 (Howden-Chapman et al, 2009:4).

The efficiency of heating appliances is important because *'more efficient heating lowers energy use, it has the potential to generate environmental benefits (less air and water pollution and lower greenhouse gas emissions) and...such benefits accrue to the wider community'* (Howden-Chapman et al, 2006:3). All home heating appliances increase indoor air temperature, however some are more efficient than others eg, open fires are generally only 10-15% efficient because lots of the heat escapes up the chimney (Howden-Chapman et al, 2009:6). Wood burners generally increase indoor temperature more than other forms of heating: *'homes heated by wood burners have been found to have higher indoor temperatures than homes heated by gas or electricity'* (Howden-Chapman, 2009:2). Nonetheless, the efficiency of wood burners varies between brands and the standards are trying to improve efficiency by providing consistency across wood burners; all burners must now test at 65% efficient to be sold as a compliant wood burner.

The World Health Organization (2004) sets out the following five major determinants of cold indoor temperatures for United Kingdom properties:

- age of dwelling (the older, the colder)
- absence of/dissatisfaction with the heating system
- cost of heating the dwelling (highest is colder)
- low household income (less is colder)
- household size (smaller is colder).

(World Health Organization, 2004:13)

These determinants are also (largely) relevant in the New Zealand context with the rising cost of power, lack of insulation, high numbers of old houses, and low socio-economic households.

Many winter deaths are due to colder temperatures. This is known as excess winter mortality (EWM). The results indicate that New Zealand experiences a similar EWM to the United Kingdom; an average of 1600 excess winter deaths (Howden-Chapman et al, 2009:3). These cannot all be attributed solely to indoor temperature but that does seem to be a key contributing factor.

The link between indoor air temperature and health has been established by many studies. *'There is increasingly clear evidence for the connection between colder weather and an increased winter hospitalisation rate in countries with lower standards of housing energy efficiency and heating'* (Howden-Chapman et al, 2009:3). Howden-Chapman showed there was an excess of hospitalisations and higher death rates in winter for those people living in socio-economically deprived areas (Howden-Chapman et al, 2009). Rheumatic pain has also been linked to humidity and temperature (World Health Organization, 2004:13). Vulnerable groups are at greater risk of being adversely affected by low temperatures. *'Colder houses place more physiological stress on older people, babies, and sick people, who have less robust*

thermoregulatory systems and are also likely to spend more time inside' (Howden-Chapman, 2007:2). Howden-Chapman and colleagues showed that insulation made a difference on indoor air temperature and health: *'the results indicated that even basic housing interventions, such as retrofitting insulation, can raise indoor temperatures and improve respiratory symptoms'* (Howden-Chapman et al, 2008:2).

3.3.4 Home Heating Appliances and Indoor Moisture and Health

Indoor air temperature is linked to indoor moisture because houses that are cold are more likely to be damp and mouldy. *'A third of New Zealand households report that their homes have mould...compared for example to only one-eighth of homes in a recent [World Health Organization] European survey'* (Howden-Chapman, n.d:2). This could be partly due to the lack of insulation in New Zealand houses as well as the living practices of occupants.

Damp increases heat loss, and while moisture in a house can come from leaking roofs or rising damp, in most houses, the major source of moisture comes from human behaviour such as steaming food or having a shower, without opening the window...If the house insulation is poor, moisture generated from cooking, cleaning and drying will condense as dampness.

(Howden-Chapman et al, 1999:7).

Unflued gas heaters create a lot of indoor moisture. The water vapour released during the combustion process contributes to dampness in the home (Howden-Chapman, 2008:2). This is a concern when almost 30% of New Zealand households own an unflued gas heater (Howden-Chapman, 2009). Excess moisture results in condensation and the spread of mould. Mould is not uncommon as it often exists in the building materials. However, it can become a problem. Homes with mould problems are likely to be in areas with high absolute humidity and have a high number of occupants who generate moisture (World Health Organization, 2004).

Adverse health outcomes of indoor moisture include the same adverse health outcomes as indoor temperature such as respiratory conditions and asthma. Respiratory health is affected by persistent damp and condensation factors as well as areas with high relative humidity (World Health Organization, 2004).

The association between living or working in a damp building and health effects such as cough, wheeze, allergies, and asthma is well established. However, it is not possible to define a damp building in health relevant terms, or to specify which agents in damp buildings have detrimental effects on health.

(Howden-Chapman, 2008:7).

The water vapour released from unflued gas heaters during combustion *'may partly explain the link between dampness and symptoms of asthma'* (Howden-Chapman, 2008:2). According to recent evidence, children are particularly susceptible to respiratory disorders and damp housing could account for 13% of childhood asthma in developed countries (World Health Organization, 2004).

Mould or fungi causes:

- irritations of the throat and eyes
- allergies (most frequently allergic rhinitis)

- lower respiratory symptoms (dry or productive cough, wheeze)
- asthma
- increased incidence of respiratory infections
- general symptoms like fatigue, headache, dizziness and difficulties in concentration (World Health Organization, 2004:12).

Mould produces mycotoxins and, when ingested, mycotoxins can cause illness and death in both humans and animals (European Federation of Allergies and Airways Diseases, 2004). *'Inhalation of high concentrations of mould spores containing these toxins may deleteriously affect respiratory health...[and] could reduce resistance to other micro-organisms perhaps resulting in chronic health problems'* (European Federation of Allergies and Airways Diseases, 2004:47).

3.3.5 The Financial Cost of Improving Indoor Air Quality

The financial cost of improving indoor air quality in relation to PM₁₀, temperature and moisture is a major issue for many households in New Zealand. New Zealanders struggle to adequately heat their homes and pay for life's other necessities partly because of the cost of electricity: *'the price of residential electricity has risen considerably faster than the rate of inflation'* (Howden-Chapman et al, 2009:5). Residential electricity rates have also risen faster than commercial or industrial rates. Not surprisingly, there is a high disconnection rate in New Zealand and many households fall behind in paying their power bills (Howden-Chapman et al, 2009). *'Home heating and quality of insulation are essential for a healthy indoor climate...but the cost of heating can lead some families to heat inadequately or use inefficient and polluting heating systems'* (Fisher et al, 2007:8).

Fuel poverty

Fuel poverty is a term used to describe households that *'need to spend 10% or more of [their]...(disposable) income on household energy, including heating the house to acceptable [World Health Organization] levels'* (Howden-Chapman et al, 2009:3). Heating can then become a trade off with other necessities ie, households may spend less on food in order to keep their house warm. More people tend to experience fuel poverty in colder regions than people living in warmer regions; 26-31% of Dunedin households were in fuel poverty compared to 6-8% of households in Auckland (Howden-Chapman et al, 2009:5). On average, 10-14% of New Zealand households were in fuel poverty in 2001 (ibid).

Those most at risk of experiencing fuel poverty are those on low incomes: *'expenditure on electricity follows a social gradient, with the lowest decile paying the highest proportion of their income on electricity...[and] the disparities may be increasing'* (Howden-Chapman et al, 2009:5). People who are renting are also at risk of experiencing fuel poverty as they also tend to be on low incomes and cannot afford to buy their own home. In addition, rental properties tend to have fewer fixed heating appliances such as heat pumps and the houses tend to be older.

Installation and operating costs

Table 3 sets out the installation and operating costs of different home heating appliances. The purpose of the table is not to say which appliance is the cheapest as that depends on a number of factors such as the brand and how efficiently the appliance is operated. Instead, the table gives an overall indication about the initial financial outlay required for the appliance versus the cost of using the appliance. It indicates that the most cost effective appliances to operate (ie, heat pumps, pellet fires) are the most expensive appliances to install. Thus, while households may make a saving in the long-term, they require substantial upfront costs. Conversely, the

cheapest appliances to install (ie, unflued gas heaters, electric fan heaters) are the most expensive to operate in the long-term. This has implications for low income households that do not have the required outlay and end up purchasing cheaper home heating appliances, particularly if they use an unflued gas heater which may also be detrimental to their health.

The table shows that wood burners are one of the more inexpensive forms of heating when they are used correctly eg, when dry wood is used. Because many people use wood burners inefficiently, they can end up costing households more than they had thought.

[A] factor often ignored in home heating costs is the “turn-down-ratio” of the appliance and the ability to control the temperature in the room. The use of too much heat output due to the appliance not being able to be regulated can lead to significant extra heating costs from unnecessary energy use, particularly if the windows need to be opened to let out the heat... Thus the popularity of solid fuel appliances is likely to be partly due to a misunderstanding of relative energy costs, rather than true costs to the householder.

(Millichamp and Wilton 2002:41)

Table 3: Installation and Operating Costs of Home Heating Appliances

Types of home heating	Installation Cost or Cost of Purchase	Operating Cost ¹² (cents/kWhr)
Open fires – coal	N/A	36.5 – 54.8
Open fires – wood	N/A	27.1 - 53
Wood burners	\$	5.4 – 9.6
Pellet fires	\$4000 - \$5000 ¹³	7.4 – 9.1
Flued gas heaters	\$2,500 – \$4,000	14.3 – 21.4
Unflued LPG gas (portable) heaters	\$180 - \$200	19.9 – 22.3
Electric fan heater	\$30 - 300	19.5 – 19.9
Heat pumps	\$3000 - \$5000	6.5 – 8.9
Oil column heater	\$30 - \$300	21 - 43 ¹⁴
Insulation	\$3000 ¹⁵	N/A

¹² Ministry for the Environment (n.d) <http://www.mfe.govt.nz/publications/energy/warm-homes-heating-options-phase1-nov05/html/images/appliance-operating-costs-including-open-fires.html>

¹³ He Kainga Oranga/the Housing and Health Research Programme, 2005:26-27

¹⁴ Consumer, <http://www.consumer.org.nz/topic.asp?category=Appliances&subcategory=Prices%20%26%20reliability&docid=2316&topic=Appliance%20running%20costs&title=Running%20costs&contenttype=summary&bhc p=1>

¹⁵ This is based on a 100²m home. Ecoinsulation, <http://www.ecoinsulation.co.nz/images/catalogues/energywise%20faq.pdf>

While relatively inexpensive to purchase, unflued gas heaters were one of the most expensive to operate, and were about the same cost as operating a fan heater. This goes against many people's perceptions that unflued gas heaters are cheap to run (Gordon, 2009).

'Potentially, [the] health benefits of installing better heating can accrue in a number of ways, such as a reduced number of visits to general practitioners, hospitalisations, days off school, and days off work' (Howden-Chapman, 2006:2). However, this relies on households being able to afford to buy, install and operate the new appliance and with some, there is a significant initial financial outlay.

One of the issues this raises in relation to the standards and the Council's proposed changes, is how people will be able to afford to replace their non-compliant open fires and wood burners with safe, cheap and healthy home heating appliances when those appliances cost so much to buy and/or install.

The issue is that the regional Council are trying to ban the use of wood fires and certain older wood burners and one suggested impact is that a number of people, particularly people in low socio-economic groups, will be forced to switch and use gas heaters and the suggestion is that gas heaters may have some health effects.

(Kingham, n.d.)

4. Conclusions

This review of key documents has been undertaken to inform the health impact assessment on the Hawke's Bay Regional Council's draft policy relating to solid fuel heating appliances and outdoor burning within the Napier and Hastings airsheds. In this policy, the Council proposed rule changes around the installation and operation of non-compliant open fires and wood burners in order to reduce the amount of PM₁₀ being discharged in the region. PM₁₀ is particulate matter that pollutes the air and causes adverse health outcomes. The main source of PM₁₀ is solid fuels in home heating appliances, particularly wood burners. Home heating appliances are the major source of air pollution in New Zealand.

The National Environmental Standards for Air Quality

The standards were set by the Ministry for the Environment and are the responsibility of unitary authorities and regional councils to implement. The Ministry for the Environment set the PM₁₀ threshold at 50 µg/m³ 24 hr average. This threshold is similar to other countries and is based on the World Health Organization's average daily threshold.

The threshold has been set on daily average PM₁₀ exposure which relates to acute health effects rather than annual average PM₁₀ exposures which relates to chronic health effects. The reason behind enforcing a 24-hour average is that many air sheds exceed the standards in winter and not in summer. This means those air sheds could have an average annual exceedence lower than 20 µg/m³ per year which is the World Health Organization's average annual threshold, but have had a number of 24-hour exceedences over the year. Enforcing average annual emissions only would not identify such short-term exceedences. It is also important to note there is no known threshold below which PM₁₀ does not adversely impact upon health. Thus, any exposure to PM₁₀ can be detrimental and setting the standard at 50 µg/m³ per day (with one exceedence allowed) may very well still be too high. From a health perspective, the standards have been set appropriately by the Ministry for the Environment.

Hawke's Bay will only be allowed to exceed the threshold once a year after 2013 before they breach the air standards. If that happens, the Hawke's Bay Regional Council may face constraints around resource consents which will have implications for the local community.

Outdoor PM₁₀ and health

PM₁₀ is so small that it bypasses the nose and mouth and gets stuck in the lungs resulting in both minor and major adverse health outcomes ranging from nose and throat irritations to premature death. Short-term exposure tends to lead to acute effects while long-term exposure tends to lead to chronic effects (Fisher et al, 2007).

Most of the studies on exposure to PM₁₀ are short-term time-series studies that show the acute effects rather than chronic conditions. Research shows there is an increase in death rates when exposed to PM₁₀ in the short-term and an even greater increase in death rates when exposed to PM₁₀ in the long-term. Research indicates that the short-term increase in death rates relation to daily levels of PM₁₀ is approximately 0.5-1% increase per 10 µg/m³ PM₁₀ increase. Research on the cumulative exposure of air pollution indicates that the effects of air pollution last longer than just a few days. However, fewer studies have been undertaken on long-term exposure to PM₁₀, so less is known about the chronic health effects. Nonetheless, the few cohort studies clearly show an association between particulates and ill health, particularly increased rates of bronchitis and reduced lung function as well as a greater increase of death rates.

There have been few epidemiological studies undertaken in New Zealand that measure the effects of PM₁₀ exposure on health. The results from one study showed that the combined effect on daily mortality of up to 40 preceding days' exposure may be much greater (on average 13-23% increase in mortality per 10 µg/m³ increase of PM₁₀) than the single-day effect'. The short and long-term research that has been undertaken seems to be consistent with findings from the international literature.

There is little evidence on the proportion of Hawke's Bay mortality and hospitalisation rates that are attributable to air pollution. However, Fisher et al (2007) calculated that approximately 27 deaths and 55 hospital admissions in Napier and Hastings are estimated to be due to air pollution annually. While there are gaps in the research, national and international studies consistently found an association between PM₁₀ and adverse health outcomes

Home heating appliances and indoor air quality (PM₁₀, temperature and moisture) and health outcomes

Home heating appliances affect indoor air quality in relation to PM₁₀, temperature and moisture. This in turn affects health outcomes. Indoor air quality is a concern in New Zealand where many homes are badly insulated, cold and damp. Thus, they often have lower indoor air temperatures than houses in other countries. Houses that are cold are more likely to be damp and mouldy, and this is exacerbated when unflued gas heaters are used as they create even more moisture and condensation.

Some research indicates that pollution levels inside the home are often similar to pollution levels outside the home due to PM₁₀ discharged from solid fuel home heating appliances. These indoor pollutants come from the smoke that is discharged from wood burners and open fires and they get trapped at a higher concentration in a smaller area. The risks to health are further compounded as indoor pollutants have as much as a 1000-fold greater chance of being inhaled than outdoor pollutants.

There are a number of adverse health outcomes due to unhealthy indoor environments. PM₁₀, low temperature and high levels of moisture cause and/or aggravate chronic conditions such as sneezing and coughing, cancer and respiratory disorders (which can also be acute eg, fatal asthma attack) to acute conditions such as fatal injuries. There is increasingly clear evidence for the connection between colder weather and an increased winter hospitalisation rate in countries with lower standards of housing energy efficiency and heating such as New Zealand. Many winter deaths are also due to colder temperatures.

Occupant behaviour is also a contributing factor to home heating appliances discharging PM₁₀, having low indoor air temperature and high levels of moisture. This can result in households spending more money on home heating because they are not using their home heating appliances efficiently.

There are currently no standards for indoor air quality in New Zealand. The National Environmental Standards for Air Quality (the standards) apply to outdoor air quality alone.

Financial costs of installing and operating home heating appliances

The financial cost of improving indoor air quality in relation to PM₁₀, temperature and moisture is a major issue for many households in New Zealand and fuel poverty is something that many New Zealanders experience due to the increased cost of daily living. Those households most at risk of experiencing fuel poverty are low income households and with the cost of electricity rising, disparities between those who can afford to spend more on heating and those who cannot, will increase.

The most cost effective appliances to operate are the most expensive appliances to install. Conversely, the cheapest appliances to install (ie, unflued gas heaters, electric fan heaters) are the most expensive to operate in the long-term. It makes sense to want to use the most cost-effective home heating appliance yet many households cannot afford the substantial upfront cost that is required to purchase them. Therefore, they end up purchasing cheaper home heating appliances that end up costing them more to operate, and are probably detrimental to their health. Unflued gas heaters fall into this category as they are relatively inexpensive to purchase, yet they are one of the most expensive home heating appliances to operate - about the same cost as operating a fan heater – and they have known adverse health impacts.

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