Domestic Fire Emissions 2012: Options for Meeting the National Environmental Standard for PM_{10}

July 2013 Technical Report 2013/022

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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July 2013 Technical Report 2013/022

Auckland Council
Technical report, TR2013/022
ISSN 2230-4525
ISSN 2230-4533

ISBN 978-1-927216-51-4
ISBN978-1-927216-52-1

This report has been peer reviewed by the Peer Review Panel using the Panel's terms of reference

Submitted for review on 13 May 2013
Review completed on 15 July 2013
Reviewed by three reviewers

Approved for Auckland Council publication by:

Name: Grant Barnes

Position: Manager, Research, Investigations and Monitoring Unit

Date: 15 July 2013

Recommended Citation:
Metcalfe, J, Sridhar, S and Wickham, L (2013). Domestic fire emissions 2012: options for meeting the national environmental standard for PM_{10}. Auckland Council technical report, TR 2013/022

Domestic Fire Emissions 2012: Options for Meeting the National Environmental Standard for PM_{10}

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Executive summary

In recent years, air quality in Auckland has exceeded health-based standards and guidelines for particulates. The particles of concern are particulate matter smaller than 10 and 2.5 micrometres in diameter (PM_{10} and $PM_{2.5}$). These can be inhaled across the blood/gas barrier in the lungs and are known to cause serious adverse health effects including cardiovascular disease and premature mortality (WHO, 2006).

Domestic fires are a major source of particulate in the Auckland region, contributing to 41 per cent of total annual PM_{10} emissions and 43 per cent of $PM_{2.5}$ emissions in 2011 (Auckland Council, 2012a). Levels are even higher during winter, with domestic fires accounting for 70 per cent of daily PM_{10} and $PM_{2.5}$ emissions on a typical winter's day. The annual social cost of health effects associated with domestic fire pollution is estimated at $411 million for the Auckland region ($NZ as at June 2010, Kuschel *et al.,* 2012).

Auckland is required to meet the national environmental standard for PM_{10} by 2016. In recognition of this, and the impact that emissions have on public health in Auckland, the Auckland Plan includes a target to reduce PM_{10} emissions by 50 per cent by 2016 (based on 2006 levels, Auckland Council, 2012c).

This study quantitatively assesses a range of policy options to reduce emissions of PM_{10} from domestic heating in Auckland. Policy options are compared with a business as usual base case and assessed in terms of how much (emission reductions) and how long (time) to effect change.

The quantitative assessment utilises the Auckland Council *Domestic Fire Emissions Prediction Model*, which has been updated for 2012 using results from the Auckland Council's 2012 home heating survey (Auckland Council, 2013). Projections are made for 2016 (the year by which Auckland must meet the national environmental standard for PM_{10}) and out to 2031 (for comparative purposes with business as usual).

Policy options assessed are summarised below:

- '**Business as usual**', which assumes that trends between 2007 and 2012 will continue.
- '**Point of sale**' rule which requires old burners and open fires to be upgraded when a house is sold.
- '**No new installations except replacements**' which prohibits the installation of new wood burners except those replacing an existing wood burner or an open fire. This effectively 'caps' the number of burners in the Auckland region.
- '**Open fire ban**' assumes that the use of an open fire is not allowed.

These were assessed individually and in combination as four 'packages'. Table 1 shows the date when each policy, or policy package, is predicted to achieve the 50 per cent emission reduction target. The table also shows the average emission reduction between 2015 and 2031 compared with business as usual. The average emission reduction isn't directly comparable with an emission reduction target. However, the average reduction does give an indication of the overall benefit of the package compared with business as usual, and provides for direct comparison of the packages.

Table 1: Summary and comparison of policy options with business as usual

Scenario	Winter PM_{10} (t/day)		Total burners		Average reduction in PM_{10} emissions*	**Achieves 50% Target**
	2016	2031	2016	2031		
Auckland Plan Target = 6.3 tonnes/day by 2016						
Business as usual	**9.7**	**6.8**	**109,200**	**113,700**	**-**	**After 2031**
Point of sale rule (old burners and open fires)	8.8	4.6	102,800	93,200	25%	2021
No new installations	9.5	5.1	105,400	80,900	11%	2026
Open fire ban	8.3	6.4	97,700	111,600	11%	After 2031
Package one: Point of sale rule No new installations	8.6	3.1	99,000	65,000	36%	2020
Package two: No new installations Open fire ban	8.1	4.7	93,800	78,800	22%	2022
Package three: Point of sale rule Open fire ban	7.5	4.5	92,700	93,000	32%	2019
Package four: Point of sale rule No new installations Open fire ban	7.3	3.0	88,800	64,700	43%	2018

* This is the average cumulative reduction in PM_{10} emissions (per cent) compared with business as usual between 2015 and 2031.

Key findings are:

- Based on an assumed six per cent turn over (in addition to business as usual), a point of sale rule for old wood burners and open fires could achieve the 50 per cent emission reduction target within six years of implemenation.
- A prohibition on the use of open fires would reduce emissions more quickly than a point of sale rule for open fires.

- Restriction of the installation of new wood burners would deliver long term benefits through a gradual reduction in the number of domestic fires in the region.

The study concludes that whilst each individual policy results in emission reductions, a combination of policies will achieve health-based air quality standards and guidelines more quickly and reduce emissions more significantly.

The most effective combination of policies is Package four which achieves the emission reduction target of 50 per cent by 2018, and reduces PM_{10} emissions by an average of 43 per cent between 2015 and 2031 compared with business as usual.

The earliest that the emissions reduction target can be met is 2018. This may put Auckland at risk of not meeting the national environmental standard for PM_{10} by 2016.

The purpose of this report is comparative analysis between business as usual and various policy options. The comparison is based on a number of assumptions, which are documented in this report. The results of this study will be used to update the analysis of costs and benefits of the policy options under consideration.

There is an opportunity to implement these policies in conjunction with insulation projects to deliver maximum benefits. Best practice air quality management for domestic emissions includes strategies that:

- regulate or influence fuel quality
- encourage good wood burner operation and flue maintenance
- educate manufacturers, retailers, installers and the general public
- partner with key stakeholders (e.g. a “good wood scheme”).

The conclusions of this study are consistent with the results of the previous *Domestic Fire Emissions: Scenario analysis* report published by the Auckland Regional Council in 2010 (Auckland Regional Council, 2010a).

1 Introduction

This report updates the *Domestic Fire Emissions: Scenario analysis* report published by the Auckland Regional Council in 2010 (Auckland Regional Council, 2010a). It updates projections of emissions to air from domestic fires and compares a range of policy options available for Auckland Council to reduce emissions to meet the national environmental standards for air quality.

The update utilises results from a home heating survey carried out by Auckland Council in 2012 (Auckland Council, 2013). These results have been input to council's *Domestic Fire Emission Prediction Model (DFEPM)* to update emissions estimates.

1.1 Background

In recent years, air quality in Auckland has exceeded health-based standards and guidelines for particulates as shown in Figure 1-1. The particles of concern are particulate matter smaller than 10 and 2.5 micrometres in diameter (PM_{10} and $PM_{2.5}$). These can be inhaled across the blood/gas barrier in the lungs and are known to cause serious adverse health effects including cardiovascular disease and premature mortality (WHO, 2006).

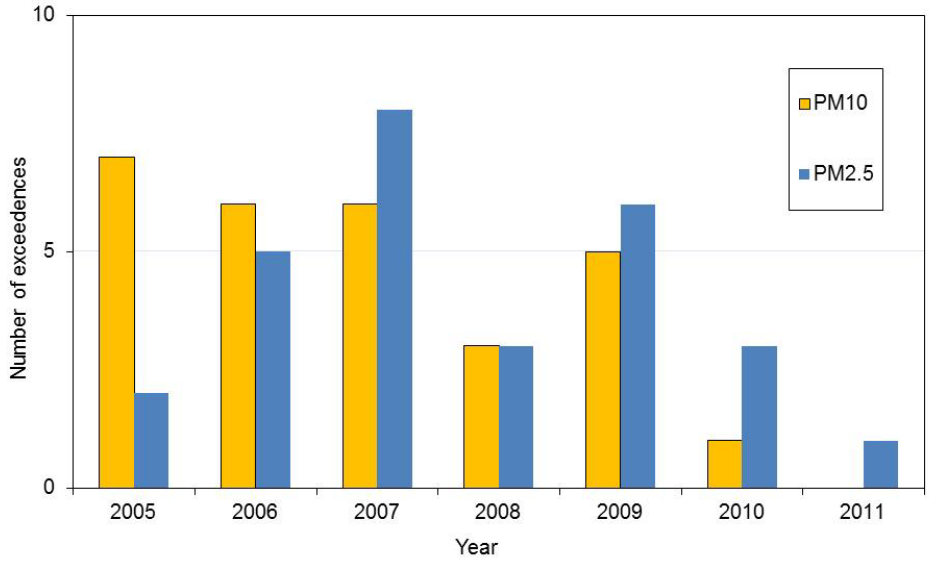


Figure 1-1: Number of days on which PM_{10} and $PM_{2.5}$ standards were exceeded in the Auckland urban airshed. between 2005 and 2011.

Domestic fires in the Auckland region are estimated to account for 41 per cent of the total annual PM_{10} emissions and 43 per cent of $PM_{2.5}$ emissions (for

2011). However, on a typical winter's, day domestic fires account for 70 per cent of daily PM_{10} and $PM_{2.5}$ emissions (Auckland Council, 2012a).

A recent study estimated the annual economic cost to the Auckland region from the health impacts of air pollution to be: ($NZ as at June 2010, Kuschel *et al.*, 2012)

- $466 million – motor vehicles
- **$412 million – domestic fires**
- $79 million – industry

Central government is primarily responsible for regulating emissions to air from transport and, since 1995, has made major progress with increasingly stringent national regulations on fuel quality and vehicle emissions control. Auckland Council has supported this through the provision of sustainable transport infrastructure, such as busways and cycleways.

The regulatory framework for air quality, and domestic emissions to air, in Auckland is described in detail below.

1.1.1 National environmental standards for air quality

In 2004, the Ministry for the Environment promulgated the *Resource Management (National Environmental Standards for Air Quality) Regulations 2004* (the regulations). The regulations include seven activity standards, five ambient air quality standards, and design standards for wood burners and landfills.

Ambient air quality standards

The regulations establish maximum concentration limits for five ambient air pollutants to *provide a guaranteed level of protection for the health of New Zealanders* (Ministry for the Environment, 2011). Ambient standards for the five air pollutants are shown in Table 1-1 below. These came into effect on 1 September 2005.

The regulations were promulgated in 2004 with the expectation of compliance by 2013. However, a Ministry review of progress in 2008 identified that 11 airsheds (including Auckland which represents nearly 30 per cent of New Zealand's population) would not comply with the ambient standards by 2013. As a result, in 2011 the regulations were amended by:[1]

[1] Resource Management (National Environmental Standards for Air Quality) Amendment Regulations 2011

- extending the compliance date for the PM_{10} standard to 1 September 2016 (in polluted airsheds) and 1 September 2020 (in heavily polluted airsheds);
- making provision for the exclusion of exceptional events (for example, dust storms or volcanic eruptions); and
- requiring offsets for new industry, and prohibiting new open fires in homes within polluted airsheds from September 2012.

The regulations now require Auckland to comply with the ambient standard for PM_{10} by 1 September 2016.

Council is also required regularly report to the Ministry for the Environment on monitoring data and progress towards targets. The Ministry for the Environment will review progress reports for the first time in September 2013.

Table 1-1: Ambient air quality standards specified by the National Environmental Standards

Pollutant	Time average	Standard	Allowable exceedances per year
Particulate matter (PM_{10})	24-hour	50 µg/m^3	1
Nitrogen dioxide (NO_2)	1-hour	200 µg/m^3	9
Carbon monoxide (CO)	8-hour (running mean)	10 mg/m^3	1
Ozone (O_3)	1-hour	150 µg/m^3	0
Sulphur dioxide (SO_2)	1-hour 1-hour	350 µg/m^3 570 µg/m^3	9 0

Wood burner standards

Design standards for wood burners also came into effect on 1 September 2005. From this date, all wood burners installed in a building on a property with an allotment size of less than two hectares must:

- Emit less than 1.5 grams of particulates per per kilogram of wood burnt; [2] and
- Have greater than 65 per cent thermal efficiency (per cent of space heating produced in comparison to the amount of energy used). [3]

[2] As measured in accordance with AS/NZS 4013:1999 Domestic Solid Fuel Burning Appliances – Method for determination of flue gas emission

1.1.2 Auckland Council Regional Plan: Air, Land and Water

The *Auckland Council Regional Plan: Air, Land and Water* (Auckland Council, 2012b, operative since 21 October 2010) includes rules for domestic fires that:

- require all new solid fuel burning fires installed in Auckland urban areas[4] to emit less than four grams of particulates per kilogram of fuel burnt.
- prohibit burning of "treated" wood/waste
- prohibit burning of dirty fuels (coal with sulphur > 0.5 per cent by weight, or wood with moisture > 25 per cent)
- prohibit nuisance to neighbours from smoke, ash or odour

Importantly, the emission limit for all new solid fuel burners effectively prohibits new open fires, coal burners and multi-fuel burners from the urban areas of Auckland (because these burners cannot meet the limit).

1.2 Auckland Plan PM_{10} emissions reduction target

The *Auckland Plan* recognises that emissions to air from the domestic, transport and industrial sectors impact on air quality and public health in Auckland (Auckland Council, 2012c). Accordingly, the plan includes the following directive and target:

- Directive 7.6: Reduce emissions from home heating, transport and other sources to improve air quality
- **Reduce PM_{10} emissions by 50 per cent by 2016** (based on 2006 levels) in order to meet national and international ambient air quality standards and guidelines, and achieve a further 20 per cent reduction by 2040.

Auckland Council estimates that PM_{10} emissions from domestic fires in 2006 were 12.6 tonnes per winter weekday (Auckland Regional Council, 2010b). A 50 per cent reduction means that emissions from domestic fires in 2016 will need to be reduced to less than 6.3 tonnes per day.

[3] As measured in accordance with AS/NZS 4012:1999 Domestic Solid Fuel Burning Appliances – Method for determination of power output and efficiency

[4] Specifically; residential, industrial and coastal air quality management areas.

1.3 Objectives of the scenario analysis

This report is an update of the *Domestic Fire Emissions: Scenario analysis* (Auckland Regional Council, 2010a). The report includes quantitative analysis to explore a range of potential policy options for reducing PM_{10} emissions from domestic fires in the Auckland region by 2016. Each policy option is evaluated against the Auckland Plan PM_{10} reduction target to achieve a required 50 per cent reduction in emissions.

The analysis uses the *Domestic Fire Emissions Prediction Model*, which was specifically designed for this purpose for Auckland Council. The model was originally developed in 2009 and designed in such a way that users have the ability to easily change key variables to evaluate other future policy options. The model has been updated with results from Auckland Council's 2012 home heating survey, in order to provide a realistic 'business as usual' scenario for comparative purposes.

1.4 Structure of the report

This report is structured as follows:

- Section 2 outlines the methodology used to estimate PM_{10} emissions from domestic fires;
- Section 3 describes the factors that influence emissions from domestic fires;
- Section 4 discusses recent trends and the business as usual projection;
- Section 5 evaluates the effectiveness each individual policy option;
- Section 6 evaluates the effectiveness of various combinations of policy options;
- Section 7 discusses the policy options available for reducing emissions from domestic fires; and
- Section 8 presents conclusions.

2 Method

This section outlines the methods used firstly to estimate PM_{10} from domestic fires in the Auckland region in 2012 and then to update the projections out to 2033 for a range of policy scenarios. The methods followed here are similar to those undertaken in *Estimation of Domestic Fire Emissions in 2006* (Auckland Regional Council, 2010b) and the *Domestic Fire Emissions: Scenario analysis* (Auckland Regional Council, 2010a).

The analysis uses the results of a home heating survey carried out in 2012.

2.1 2012 home heating survey

A home heating survey was undertaken in 2012 (Auckland Council, 2013) as an update to a comprehensive survey conducted in 2007 (Auckland Regional Council, 2010c). The surveys provide vital information on the type, and age, of burners as well as information on trends in domestic heating.

Some key statistics from the surveys undertaken in 2007 and 2012 are shown in Table 2.1.

Table 2-1: 2007 and 2012 Home Heating Surveys

2007 Survey	2012 Survey
7,231 respondants	2,800 respondants
29% burn wood	26% burn wood
Type of domestic fire: o 72% wood burners o 23% open fires o 5% multifuel burner o 1% pellet burners	Type of domestic fire: o 77% wood burners o 17% open fires o 4% multifuel burner o 2% pellet burner

2.2 Estimation of domestic fire emissions in 2012

PM_{10} emissions from domestic fires in 2012 have been estimated to provide for scenario analysis.

Domestic fire emissions are estimated for each type of domestic fire as follows:

*Emission (g) = number of domestic fires * emission factor (g/kg fuel) * fuel use (kg)*

For this report, the number of domestic fires has been updated as described in the following sections.

2.3 Types of domestic fires

A domestic fire is any indoor fire in a place of residence and may be used for heating space, water or cooking. There are many types of domestic fires including:

- Open fires;
- Wood burners (categorised by age):
  - Pre-1991 wood burners
  - 1991 - 2005 wood burners
  - Post-2005 (installed from 2005 and onwards, also referred to as a NES wood burner)[5]
- Multi-fuel burner;
- Coal burner
- Pellet burner; and
- Range/stove.

All of these domestic fires are considered to be solid fuel burners as they are used to burn wood and/or coal. For the purposes of this report, pre-1991 wood burners, 1991-2005 wood burners, multifuel burners, coal burners, pot bellies and range/stoves are all classified as 'old burners' (these are highlighted in grey in Figure 2-2 below).

[5] NES wood burners are assumed to comply with the design standards in the national environmental standards for air quality (refer Section 1.1.1).

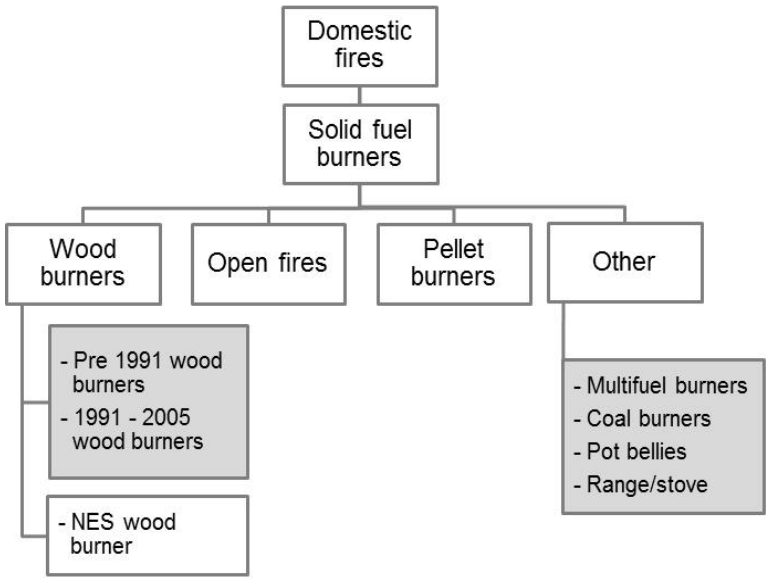


Figure 2-1: This diagram shows the types of domestic fires available in the region, and those categorised for the purpose of this report as 'old burners' (in grey).

2.4 Estimating burner numbers

The number of each type of domestic fire is estimated as:

number of domestic fires = HH x PT x PA

Where:

HH = no. of households using specified fuel (wood or coal) for heating (from the Census)

PT = Proportion of households using each domestic fire type (from the home heating survey)

PA = Proportion of domestic fire in age group (from the home heating survey)

In the Auckland emissions inventory, the overall number of households using wood or coal is based on the Census because this is the most accurate data available. However, the scheduled (five-yearly) census was not undertaken in 2011 due to the Christchurch earthquake. For this study, the number of households burning wood in 2012 is based on data from the previous census (Census 2006). This means that the current projections are based on the assumption that there is no significant change in the number of households burning wood. This assumption is consistent with the results of the 2007 and 2012 home heating surveys, as discussed in Section 4.

The type and age of domestic fires is estimated based on the results of the 2012 home heating survey. The approximate number and type of burners for 2012 are compared with previous years in Table 2-2 below.

The 2001 burner numbers were estimated based on the 2001 census and the 2002 home heating survey and 2006 burners were based on 2006 census and the 2007 home heating survey as (described in *Estimation of Domestic Fire Emissions in 2006* (Auckland Regional Council, 2010b).

Table 2-2: Approximate number of domestic fires based on the 2002, 2007 and 2012 surveys.

	2001	2006	2012
Old burners	88,000	78,000	67,000
Open fires	28,000	26,000	18,000
NES burners	0	5000	24,000
Pellet burners	0	1000	1000
Total burners	**116,000**	**110,000**	**110,000**
PM_{10} emissions (kg/winter weekday)	13,855	12,555	11,045

2.5 Emission factors and fuel use

Emission factors used are summarised in Table 2-3. These and estimates of fuel use remain the same as those reported in *Estimation of Domestic Fire Emissions in 2006* (Auckland Regional Council, 2010b).

Fuel use was based on the 2007 home heating survey (Auckland Regional Council, 2010c) which showed that wood burners were used more often in a week, and for longer periods, than open fires. This is most likely a result of people using open fires in conjunction with other forms of heating (e.g. electricity) and reflects the lower thermal efficiency of open fires compared with enclosed wood burners.

The survey also estimated an average daily fuel use for wood burners of 14 kilograms per winter weekday and an average daily fuel use for open fires of 10 kilograms per winter weekday. So, although emission factors for open fires are higher, less fuel is used in open fires across the region and as a result, open fires have a lower overall emission than for pre-1991 wood burners.

Table 2-3: Domestic fire emission factors (g/kg, wet weight) for PM_{10}[6]

Type of burner	PM_{10} emissions (g/kg) [a]	Average fuel use (kg/day) [b]	Average emission (kg/day) [b]
Open fires (wood)	12	10	0.12
Pre-1991 wood burners	10.7	14	0.15
1991 – 2005 wood burners	7.2	14	0.10
Post 2005 (NES) wood burner	3.7	14	0.05
Multifuel (wood) burner	10.7	14	0.15
Pellet burner	1.4	5	0.01

[a] grams per kilogram wet weight, [b] average winter day

2.6 Emissions from coal burning

Emissions from coal burning are not specifically considered in this report. The use of coal in the Auckland region is minor in comparison with wood used for heating and there is not enough data to estimate trends. It is reasonable to assume that, without any policy intervention, emissions from coal burning will remain unchanged from the 2006 estimate of approximately 0.3 tonnes PM_{10} per winter weekday.

2.7 Domestic Fire Emission Prediction Model

The *Domestic Fire Emission Prediction Model* was originally developed by the Auckland Council (formerly Auckland Regional Council) in 2009. The model uses data from the council's home heating survey and census data to predict regional PM_{10} emissions from domestic fires and analyse policy options.

The model also projects emissions out to 2033 for various scenarios, including an updated business as usual scenario. Under these scenarios, the assumption is that the emission factors and fuel consumption do not change over time for each type of domestic fire. Emissions change over time due to changes in the number and type of domestic fires in the region.

2.8 Projections of domestic emissions to 2033

The results of the 2012 home heating survey have been used to update the *Domestic Fire Emissions Prediction Model*. The updated business as usual scenario and projections for a range of scenarios are presented in this report.

[6] Fuel use and emission factors from Auckland Council, 2010b.

The assumptions for the updated business as usual projection are described in Section 4 of this report. The assumptions and results of scenario analysis are described in Sections 5 and 6.

3 Factors that influence domestic fire emissions

A comprehensive strategy to reduce domestic fire emissions needs to consider all of the factors that influence emissions, which include:

- Fuel quality (wood type, moisture, and size);
- Wood burner operation;
- Wood burner and flue maintenance;
- Level of insulation in homes;
- Emission standards for new wood burners; and
- Domestic fire turnover.

The following subsections discuss each of these factors, highlight their potential influence on emissions, and indicate possible options for policy intervention.

3.1 Fuel quality

The quality of wood used for fuel and its subsequent impact on emissions depends upon the type of wood, its moisture content and size.

Council promotes the use of 'seasoned' wood for fuel. Seasoning is the process of removing moisture and volatile organic compounds (VOCs) from wood. Freshly cut wood can hold up to 50 per cent of its "wet" or "green" weight as moisture. Seasoning can take six to 12 months for softwoods (such as pine) and one to two years for hardwoods (such as eucalyptus and manuka).

Burning wet or green wood increases emission rates by over 70 per cent more than dry wood (Auckland Council, in press). A modern wood burner, therefore will not achieve low emissions if the fuel is either unseasoned or wet.

Similarly, the size of logs used as fuel has also been shown to influence emissions and it is recommended to burn pieces no larger than 110 mm in diameter (Auckland Council, in press).

There is the potential for enforcement or a "targeted education" to increase public awareness around burning wet or damp wood. Requirements in the Auckland Council Regional Plan: Air, Land and Water state that wood moisture content must not exceed 25 per cent (of dry weight) for any fuel burnt in a wood burner.[7]

[7] Rule 4.5.10 in the *Auckland Council Regional Plan: Air, Land and Water*. Part 2, Chapter 4: Air Quality. (Auckland Council, 2012b)

Nelson City Council and Tasman District Council have a voluntary "Good Wood Supplier" scheme for approved retailers to supply firewood according to best practice. It may be advantageous for Auckland Council to run a similar scheme in Auckland. However, the 2007 home heating survey found that Auckland had a relatively high rate (65 per cent) of self-collection of wood (Auckland Regional Council, 2010c). This may limit the effectiveness of a "good wood" scheme which, by necessity, only targets purchased wood.

3.2 Wood burner operation

A modern wood burner will not achieve low emissions if it is not correctly operated, broken or tampered with. In the past, many homeowners used to bank up their fires and then "damp down" the fireboxes overnight to allow for an easier start up in the morning. However, this practice resulted in excessive emissions due to the lack of oxygen for complete combustion. Newer wood burners cannot be "damped down" but optimum performance still relies on householders knowing how to correctly set and feed an efficient fire.

Public education initiatives have the potential to improve awareness of correct operating procedures. Nelson City Council ran a targeted education programme with an environmental educator who responded to feedback about smoky chimneys and provided assistance to homeowners to help them with regional plan rules. This was received with a positive response from the public.

3.3 Wood burner and flue maintenance

Annual inspection and cleaning of flues and wood burners or open fires is recommended by wood burner manufacturers, the New Zealand Home Heating Association and the New Zealand Fire Service. However, council does not have any information on the effectiveness of this advice.

Annual maintenance of wood burners could be considered as part of a policy package. Alternatively, council could work with home insurance providers to encourage annual maintenance and inspection.

Additional data (e.g. an additional question in the next home heating survey) would help to assess the necessity of these options.

3.4 Level of insulation in homes

Adequate insulation results in health, energy efficiency and air quality benefits (because less heating is required in a well-insulated house). Many homes are still below the World Health Organisation's recommended residential indoor temperature of 20-22°C during winter despite steady increases in household energy use (WHO, 1988).[8] In a 2009 assessment, Auckland Council estimated up to 27 per cent of houses in the region are likely to have little or no insulation (Auckland Regional Council 2009).

The Energy Efficiency and Conservation Authority (EECA) estimates that every $1 spent in retrofitting insulation results in about $5 of benefits (Motu, 2012). Accordingly, there are a number of government funded programmes to incentivise retrofitting of insulation:

- "Retrofit Your Home" programme targets houses that were built before 2000 and meet certain additional criteria. Auckland Council provides financial assistance to be repaid through a targeted rate to improve home insulation (and/or upgrade to cleaner forms of heating).[9]
- "Warm Up NZ: Heat Smart" is an insulation programme that started in July 2009 by EECA as a four year programme.The programme provides grants for insulating homes across New Zealand. Almost 25,000 homes have been retrofit with insulation only under the programme between July 2009 and December 2011.[10]
- "Snug Homes" is a home insulation programme available to residents of Auckland central and Counties Manukau only. It targets houses built before 2000, owners or tenants with community services cards, or families living in cold/damp living conditions. Since July 2009, almost 3,700 homes have benefitted from insulation retrofits under this scheme.[9]
- "Warm n Well" is the Waitemata District Health Board's scheme which provides families with free home insulation and a comprehensive health assessment. To be eligible families must live in the West Auckland, Rodney and North Shore areas and have children aged under 14 years. Almost 800 homes have benefitted from the scheme since July 2009.[9]

The impact of these insulation retrofit programmes on domestic heating emissions has not been specifically quantified in the business as usual scenario. However, any significant changes in the types of domestic fires, will

[8] The World Health Organisation (WHO) also recommends a minimum temperature of 18°C in bedrooms at night.
[9] Personal comm. J Hatton, Auckland Council 31 January 2013
[10] Personal comm. D Birchfield, Auckland Council 31 January 2013

be captured in the results of the 2012 Home Heating Survey (Auckland Council, 2013), which is incorporated into the model.

3.5 New domestic fire emission standards

The national environmental standards for air quality set a particulate emission limit of 1.5 grams per kilogram of wood burned for new wood burners on any property less than two hectares. The *Auckland Council Regional Plan: Air, Land and Water* sets a particulate emission limit of 4.0 grams per kilogram of wood burned for all solid fuel burners in specified air quality management areas. These overlap to some extent, but in general, in all urban areas of Auckland:

- New wood burners must emit particulates less than 1.5 grams per kilogram of wood burned; and
- New open fires, coal burners and multi-fuel burners are prohibited (because they cannot emit particulates less than 4.0 grams per kilogram of wood burned).

These emission limits are based on a laboratory test method (AS/NZS 4013:1999) in which all aspects of the fuel and operation of the burner are carefully controlled so as to ensure repeatability and comparability between different burners. Emissions testing has shown that emissions from wood burners under normal operation (i.e. real life) are usually much higher than tests conducted under laboratory conditions. Emission estimates in this quantitative analysis are based on real life emission factors (developed by Auckland Council), as opposed to laboratory certified emissions performance.

There is some uncertainty about the ongoing performance of a wood burner. For example, whether emissions from a wood burner will increase as the burner gets older, and if so, by how much.

3.6 Domestic fire turnover

Any strategy to significantly reduce emissions from domestic fires will need to consider options to accelerate retirement of the oldest domestic fires, and encourage clean alternatives. There are a range of options that have been considered and adopted by other regions to date. These include:

- No installations of new solid fuel burners (except replacements) (e.g. Nelson, Christchurch);

- Restricting the installation of new solid fuel burners through regional plan rules (e.g. Christchurch);[11]
- Requiring an upgrade of old wood burners or open fires when a property is sold (point of sale rule) (e.g. Hawke's Bay, Rotorua, Richmond);
- Restricting the use of existing high emission older wood burners and open fires through regulation (for example, to require all domestic fires be upgraded by a certain date) (e.g. Nelson, Christchurch); and
- Implement incentives to accelerate replacement of existing old wood burners and open fires with low emission alternatives. Incentives include full

Scenario	PM_{10} (t/winter	Emissions at or below 2016	Number of burners in 2016

assistance (such as under the Energy Efficiency and Conservation Authority's Energywise programme) , subsidies or loans (e.g. Auckland Council's Retrofit Your Home programme, Christchurch, Nelson).

To provide an indication of the extent of change that would be required to meet the emission reduction target in Auckland, Table 3-1 shows the effect of **hypothetical** scenarios. This shows that, in order to meet the target, almost all of the old burners and open fires in the region would need to be converted to a NES wood burner. Reducing the number of old burners and open fires by 45 per cent would also meet the target. However, these step changes are not realistic. A number of more realistic policy options to encourage retirement of old burners and open fires are evaluated in the following sections of this report.

[11] For example, in Christchurch the regional rules specify solid fuel burners meeting an emission limit of 1.0 g/kg as a permitted activity – but only in homes that previously had a burner (thus preventing new emissions in the airshed). However, pellet burners in new homes which previously have not had a burner are a restricted discretionary activity and may be installed with resource consent. Similarly, in rural Canterbury non-NES compliant burners are a non-complying activity and may be installed on a property greater than 2 hectares in size with resource consent.

	(t/winter weekday) in 2016	or below 2016 target of 6.3 t/winter wkday?	Old wood burners	Open fires	NES burners
Base case in 2016	9.7	No	56,700	13,100	37,900
All open fires are removed	8.3	No	56,700	Nil	37,900
All old wood burners and open fires are converted to NES wood burners	5.7	Yes	Nil	Nil	107,800
The number of old wood burners and open fires is reduced by 45%	6.3	Yes	31,200	7,200	37,900

Table 3-1: Hypothetical step changes in appliance numbers compared with 2016, to illustrate the extent of reduction required to meet the 50 per cent emission reduction target.

4 Trends and projections

This section discusses the recent trends in wood burner emissions and ambient air quality. The 'business as usual' projection in the Domestic Fire Emission Prediction Model (DEFPM) is based on the assumption that recent trends will continue. The methods followed here are similar to those undertaken in *Domestic Fire Emissions: Scenario Analysis* (Auckland Regional Council, 2010a).

4.1 Trends

Census data from 1996 to 2006 shows that although the number of dwellings in the region has increased, the number of dwellings that use wood for heating has decreased over this 10 year period.

The 2011 Census was not held as planned due to the Christchurch earthquake, so as a result, overall trends can only be assessed until 2006. Figure 4-1 shows the dwelling and heating trends for the Auckland region since 1996. The data shows that the number of households using wood for heating reduced by five per cent between 2001 and 2006 in the region.

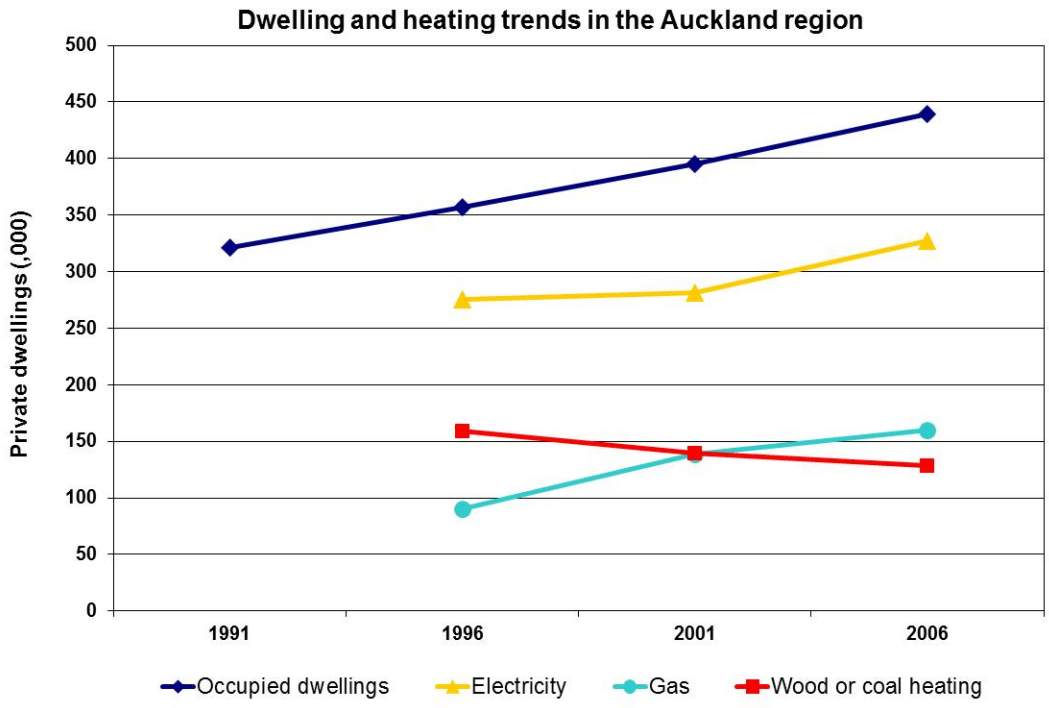


Figure 4-1: Dwelling and heating trends for the Auckland region (Census data)

For this report, it is assumed that there has been no change in the total number of households burning wood between 2006 and 2012. This is consistent with the findings of the 2007 and 2012 surveys. According to the 2006 census, there were approximately 110,000 households using wood for heating in 2006, as shown in Table 4-1. The estimated number of households using wood for heating based on the results of the 2007 and 2012 home heating surveys was approximately 126,000 and 127,000 respectively as shown in Table 4-2. Although these results are higher than the census estimate of 110,000 households, the two survey results are similar. This suggests that there has been no significant change in the number of households using wood for heating. So, to maintain consistency with the previous report, the number of households burning wood in 2012 is based on 2006 census data.

Table 4-1: Census data for households and wood use in 2006 and household projection for 2012

	2006	**2012**
Total number of households in the region	437,998	485,021*
Private dwellings using wood for heating (census)	25%	
Total number of households using wood for heating (census)	**110,000**	

* estimated using the Auckland Futures Growth Model based on 2006 Census, Auckland Council (2013)

Table 4-2: Survey data for households using wood in 2006 and 2012

	2006	**2012**
Percentage of respondents using wood for heating (2007 and 2012 home heating surveys)	29% ± 1%	26% ± 3%
Estimated number of households using wood for heating based on survey results.	**127,000**	**126,000**

Figure 4-2 displays the trends in domestic fire numbers between 2001 and 2011. The method for estimation of domestic fire numbers is described in Section 2.2.

Figure 4-2 shows that the number of old burners and open fires has reduced since 2001, while the number of new wood burners (NES burners and pellet burners) has increased during this time. Figure 4-2 also illustrates the reduction in PM_{10} emissions as a result of the introduction of the NES wood burner standards (which took effect in 2005) and overall reduction in burner numbers (between 2001 and 2006). It is estimated that PM_{10} emissions reduced by approximately 20% between 2001 and 2011.

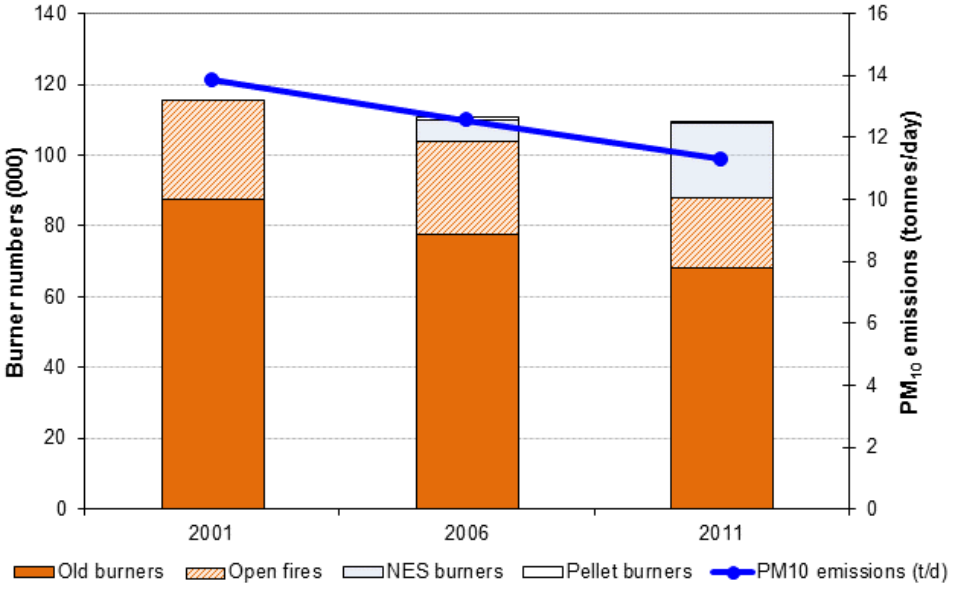


Figure 4-2: Estimated burner numbers in 2001, 2006 and 2011.

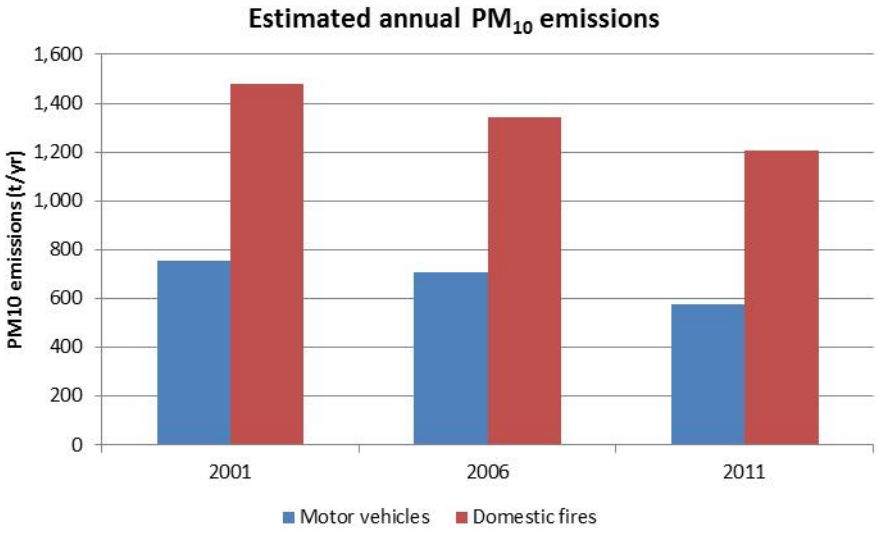
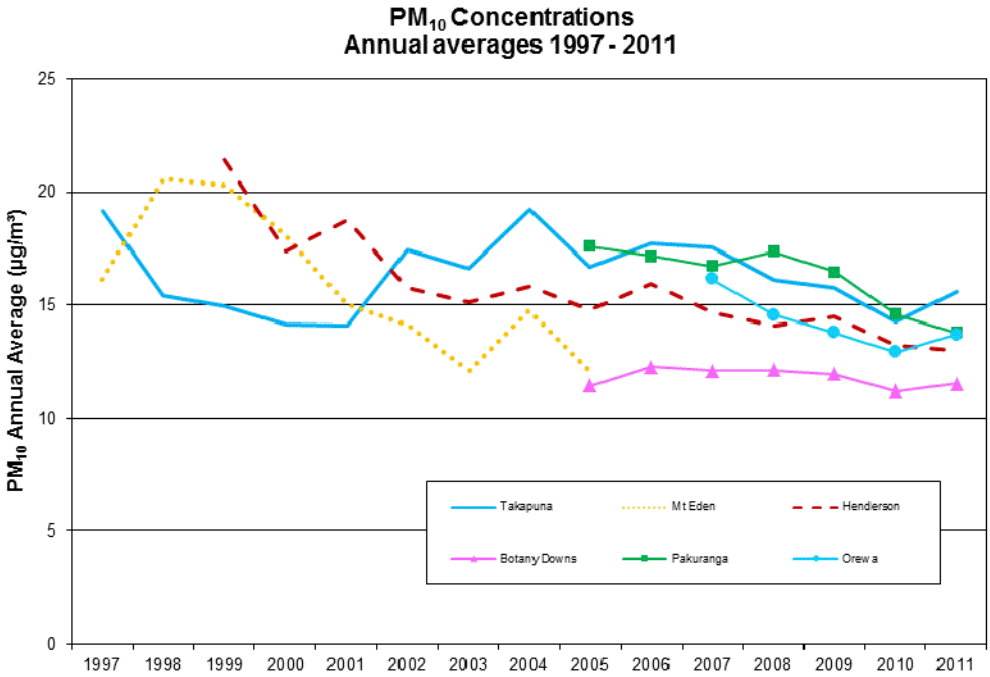


Figure 4-3: Estimated annual PM_{10} emissions in 2001, 2006 and 2011.

Although estimated PM_{10} emissions from both domestic fires and motor vehicles have reduced by almost 20 per cent between 2001 and 2011 (Figure 4-3), annual average PM_{10} concentrations at Auckland residential monitoring sites show no consistent trend (Figure 4-4). There has been a gradual drop in PM_{10} concentration at some monitoring sites, while the concentration at other sites has remained stable. This is because ambient air quality is influenced and affected by a range of factors such as meteorology, local topography and other



emission sources, as well as the emissions from domestic fires and motor vehicles.

Figure 4-4: PM_{10} annual average concentrations at Auckland residential monitoring sites

The long term trend for $PM_{2.5}$ shows no clear trend in annual average concentrations as shown in Figure 4-5.

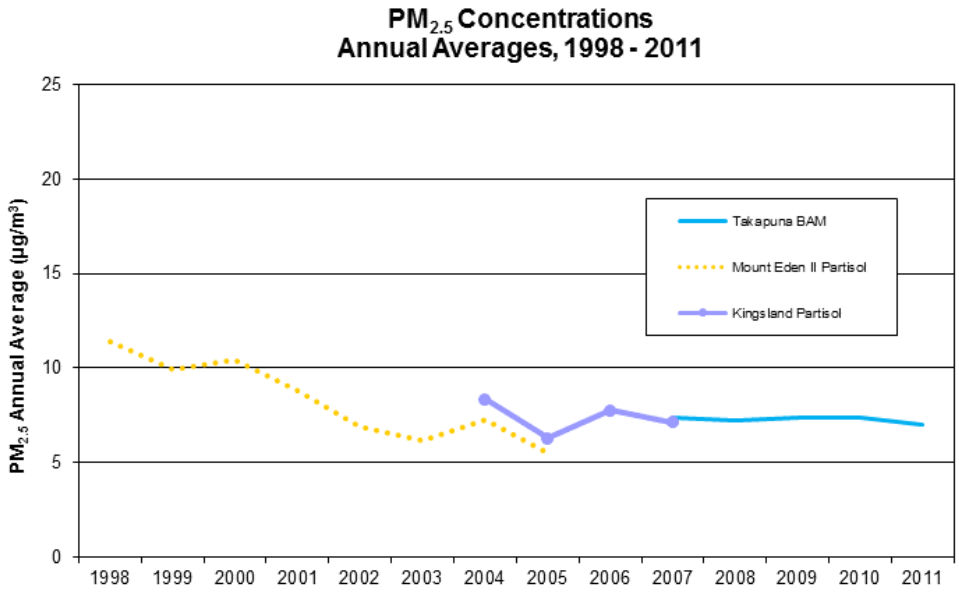


Figure 4-5: $PM_{2.5}$ annual average concentrations at Auckland residential monitoring sites

4.1.1 Business as usual

The business as usual scenario in the *Domestic Fire Emission Prediction Model* (DFEPM) reflects trends from 2006 to 2012 and assumes that these trends will continue out to 2033. Assumptions are provided in Section 4.2.

Previous analysis (Auckland Regional Council, 2010a) has demonstrated that the business as usual scenario is sensititve to the assumptions made about the rate of retirement of old burners and uncertainty around whether emissions from modern post 2005 (NES compliant) wood burners will increase over time.

4.1.2 Policy scenarios

A range of policy scenarios were tested in the DFEPM to evaluate the best options available to reduce emissions from domestic fires. The policy options considered are outlined below:

- A point of sale rule for wood burners and/or open fires;
- No new installations allowed except for those replacing existing burners; and
- An open fire ban.

The various policy scenarios and associated assumptions are described in Section 5 of this report.

4.2 Business as usual projection

The business as usual projection for the Auckland region is summarised in Table 4-2 and Figure 4-6.

Table 4-2: Summary of business as usual compared with the Auckland Plan target: 2016 and 2031

Scenario	Winter PM_{10} (tonnes/day)	Number of burners			
		Old wood burners	Open fires	NES burners	Total burners
Auckland Plan Target	**6.3**				
Business as usual					
2016	9.7	56,700	13,100	37,900	109,200
2031	6.8	15,000	3,600	90,900	113,700

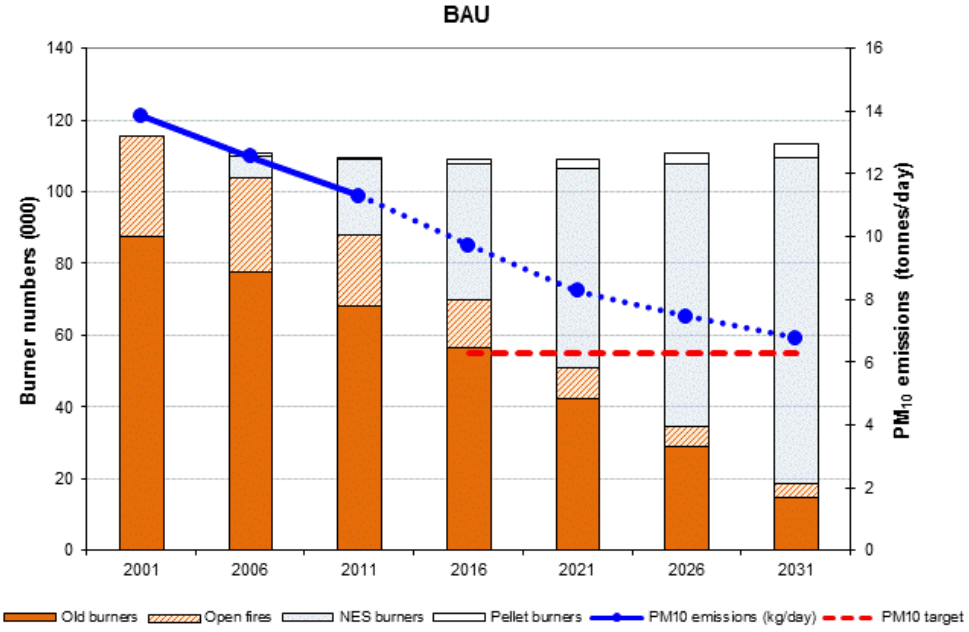


Figure 4-6: Business as usual emission projection assuming that current trends continue.

Under business as usual:

- The Auckland Plan reduction target is not achieved until after 2031.

- Winter week day PM_{10} emissions are 9.7 tonnes per day in 2016. This is a reduction of approximately 23 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).

Under business as usual, PM_{10} emissions gradually reduce as old burners are retired, and new low emission NES burners and pellet burners are installed.

4.2.1 Assumptions for the business as usual projection

As mentioned earlier, business as usual is based on recent changes in the number of burners and burner types, based on the 2007 and 2012 home heating survey. The underlying assumptions for these estimates for business as usual are outlined below:

- The annual retirement of wood burners (approximately 2,200 per annum in 2013) is based on the change in burner numbers between 2007 and 2012. This is assumed to change in proportion to the total number of wood burners in the region.
- The oldest wood burners are retired first.
- The rate of retirement of open fires is assumed to be eight per cent per annum. This is the per cent reduction based on differences between the 2007 and 2012 home heating surveys.
- In 2013 there are approximately 3,700 burner retirements per annum in the Auckland region. This includes approximately 2,200 old burners (all pre-2005 wood burners and multifuel burners) and 1,500 open fires.
- It is assumed that there are approximately 3,800 wood burner installations per annum in the region. It is assumed that all new installations are NES wood burners.
- Emissions are only estimated for open fires in active use. This is based on the 2012 home heating survey which estimates around 18,500 open fires in use compared with estimated population of 64,000 open fires in total.
- The pellet burner installation rate is assumed to be five per cent of the wood burner installation rate.
- The model assumes perfect and complete implementation of regional and national regulations for wood burners, i.e.;
  - No new multifuel burners or open fires are installed in accordance with the wood burner rules in the Auckland Council Regional Plan: Air, Land and

Water. It is noted that installations of multifuel burners and open fires are permitted in rural areas under the regional plan. These are considered unlikely to make a significant difference to overall burner numbers and emissions.

- There are no installations of new wood burners that do not comply with the national environmental standards for air quality. Whilst in reality unregulated installation of burners may occur, for comparative purposes, it is reasonable to ignore this.

- The model assumes perfect and complete implementation of the policy options and packages under consideration. This is necessary and reasonable for a comparative assessment.

- Old burners that will be retired under the Auckland Council "Retrofit your Home", or EECA's Clean Air grants, have not been specifically included in the projections.[12] This is to avoid 'double counting' burners being phased out due to a policy option with those are incentivised to upgrade through funding. For example, a burner that is required to be upgraded due to a point of sale rule may still successfully receive funding from Auckland Council under the Retrofit your Home programme.

- The rules in the existing regional plan (i.e. emission limit of 4.0 grams of particulate for every kilogram of fuel burnt) are assumed to remain in place. Business as usual therefore assumes:

  - No new installation of open fires or multi-fuel burners (because they cannot meet the regional plan emission limit).

  - The rules take effect over the Auckland region (despite only applying in practice to specified air quality management areas).

[12] Under the Retrofit your Homes programme, an additional 500 homes will be retrofitted with clean heat options each year, for 10 years from 2012.

5 Evaluation of individual policy options

This section discusses the individual policy options proposed for reducing emissions from domestic fires. Emission reductions achieved in each scenario are compared against the emissions reduction target of 50 per cent and business as usual as summarised in Table 5-1 (burner numbers in this table, and subsequent analyses, are rounded to the nearest 100).

Each policy scenario is assumed to be implemented as a stand-alone policy and effective from 2015. The 2015 date has been selected as a starting point and can easily be changed in the Domestic Fire Emission Prediction Model.

Given the assumptions involved, the key advantage of this modelling is to provide a comparative assessment relative to business as usual (also presented in Tables 5-1 and 5-2). Individual policy options are discussed in detail below.

Table 5-1: Summary and comparison of business as usual with individual policy options: 2016

Scenario	2016 Winter PM_{10} (tonnes/day)	Number of burners in 2016			
		Old wood burners	Open fires	NES burners	Total*
Auckland Plan Target = 6.3 tonnes/day by 2016					
Business as usual	**9.7**	**56,700**	**13,100**	**37,900**	**109,200**
Point of sale rule	8.8	49,700	11,500	39,400	102,800
No new installations	9.5	56,700	13,100	34,100	105,400
Open fire ban	8.3	56,700	0	37,950	97,700

* Totals presented here include the number of pellet burners, and therefore will not add up to the sum of old wood burners, open fires and NES burner numbers.

5.1 "Point of sale" rule

A "point of sale" rule requires old domestic fires (i.e. pre 2005 wood burners, coal burners and multi-fuel burners) and open fires to either be replaced or not used, after a house is sold. Figure 5-1 shows the types of burners assumed to be affected by this policy. It is assumed that the "point of sale" rule impacts old burners as well as open fires, except in policy packages where there is an open fire ban.

The old burner or open fire may be replaced with either a wood burner that meets the national environmental standards for air quality (a NES post-2005 wood burner), or a clean heat alternative (pellet burner, heat pump etc.).

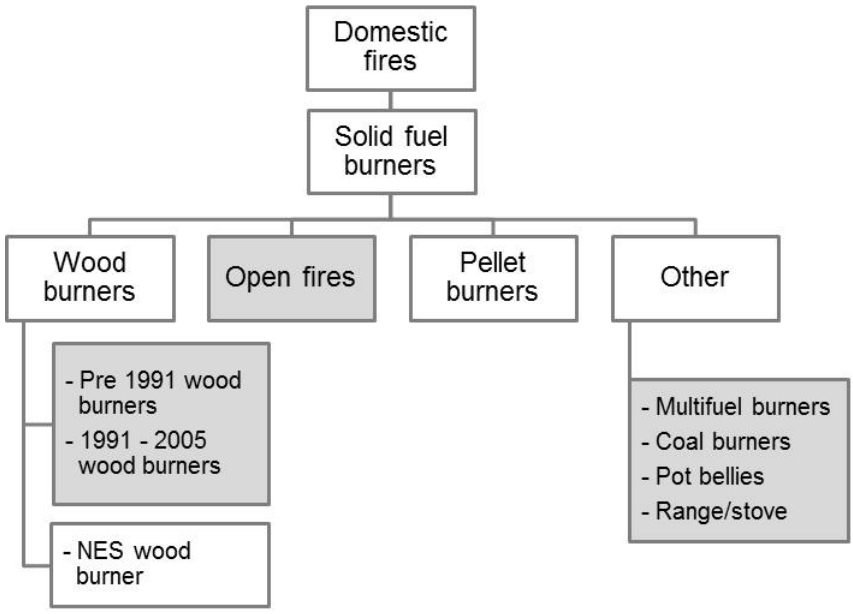


Figure 5-1: Diagram showing the types of burners affected by a point of sale rule (in grey)

A point of sale rule does take time to deliver results because it depends on how frequently the housing stock turns over. Annual house sales in Auckland vary between a (10 year) high of 10 per cent (2003) and a low of six per cent (2008).[13] It is anticipated that typical turnover is around seven to eight per cent. In other words, around seven to eight per cent of all houses in Auckland are sold each year.

For the point of sale rule scenario, it is assumed that six per cent of the remaining old wood burners and/or open fires are retired in addition to the business as usual retirement.

The point of sale rule differs from business as usual as follows:

- Six per cent of old wood burners and open fires are retired each year due to the point of sale rule **in addition** to business as usual retirement from 2015.
- It is assumed that 20 per cent of retired domestic fires are replaced with NES wood burners, and 10 per cent with a pellet burner. The remainder of the

[13] Quotable Value February 2013. Available at: http://www.qv.co.nz/propertyinformation/KnowledgeCentre/residentialsalesturnover05022010.htm

retired domestic fires are assumed to be replaced with a low emission alternative such as a heat pump. This assumption is unchanged from the previous report (Auckland Regional Council, 2010a).

5.1.1 Point of sale rule projection

Projected emissions under a point of sale scenario for old burners and open fires for Auckland are shown in Figure 5-3 below. Under the point of sale rule:

- The Auckland Plan reduction target is achieved by 2021.
- An average emission reduction of 200 tonnes of PM_{10} per annum between 2015 and 2031, or 25%, is achieved compared with business as usual.
- In 2016:
  - Win ter week day PM_{10} emissions are projected to be around 8.8 tonnes per day. This is a reduction of approximately 30 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).
  - Win ter week day PM_{10} emissions are approximately nine per cent lower than business as usual in 2016.

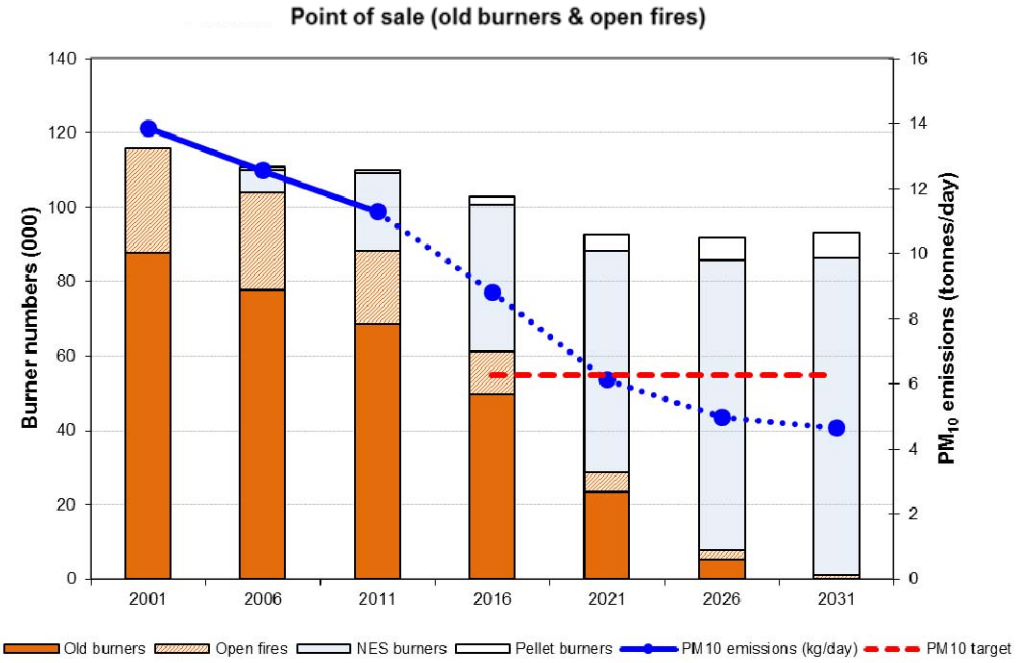


Figure 5-2: Domestic fire PM_{10} emissions for a point of sale rule for old burners and open fires from 2015.

5.2 No new installations except replacements

Under this option, it is assumed that no new burners are installed in any dwelling from 2015, except for the replacement of already existing wood burners or open fires. This effectively "caps" the number of wood burners allowed in the region.

The no new installations policy is based on the following assumptions:

- The number of new burners being installed each year is reduced to approximately 44 per cent of the number installed each year under business as usual installation. The percentage in each area is based on the surveyed estimate of the proportion of wood burners that were installed to replace an open fire or wood burner from the 2007 home heating survey.
- The retirement rate for old wood burners is assumed to be the same as business as usual.

5.2.1 No new installations projection

Projected emissions for the no new installations scenario are shown in Figure 5-4 below. Under this scenario:

- The Auckland Plan reduction target is achieved in 2026.
- An average emission reduction of 91 tonnes of PM_{10} per annum between 2015 and 2031, or 11%, is achieved compared with business as usual.
- In 2016:
  - Winter week day PM_{10} emissions are projected to be around 9.5 tonnes per day. This is a reduction of approximately 24 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).
  - Winter week day PM_{10} emissions have reduced by only two per cent compared with business as usual.

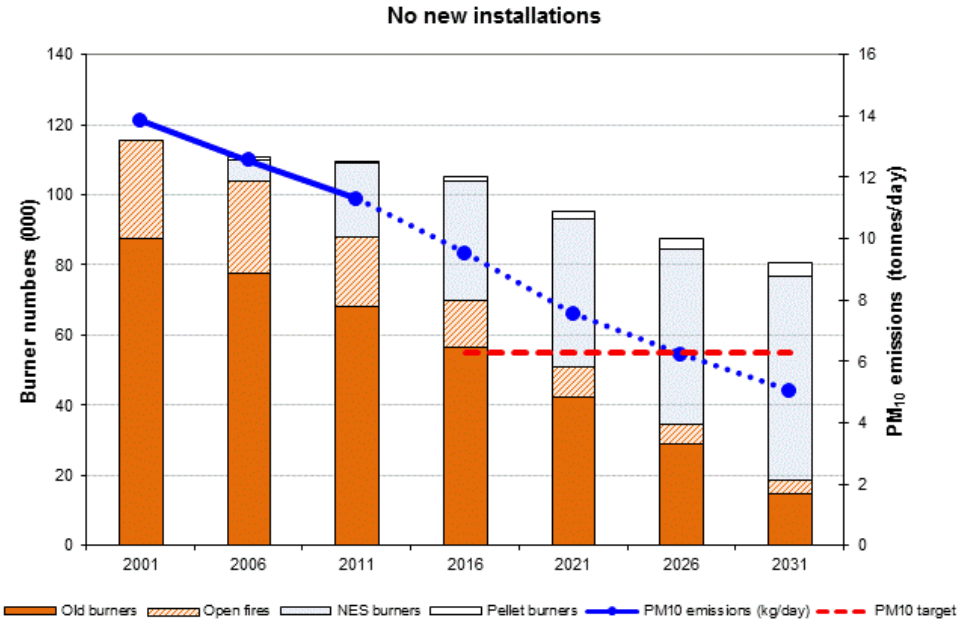


Figure 5-3: Domestic fire PM_{10} emissions for no new installations except replacements from 2015.

5.3 Open fire ban

Key assumptions for modelling emission of an open fire ban are:

- The ban takes effect in 2015 with zero emissions from 15,000 existing open fires after this date.
- As with business as usual, only emissions from open fires in active use are included in the modelling.
- No open fires are replaced with a wood burner or pellet fire. This may not be realistic, however sensitivity analysis in the *Domestic Fire Emissions: Scenario Analysis* (Auckland Regional Council, 2010a) showed that the emissions are not sensitive to this assumption.

Figure 5-5 shows the type of burners affected by this scenario.

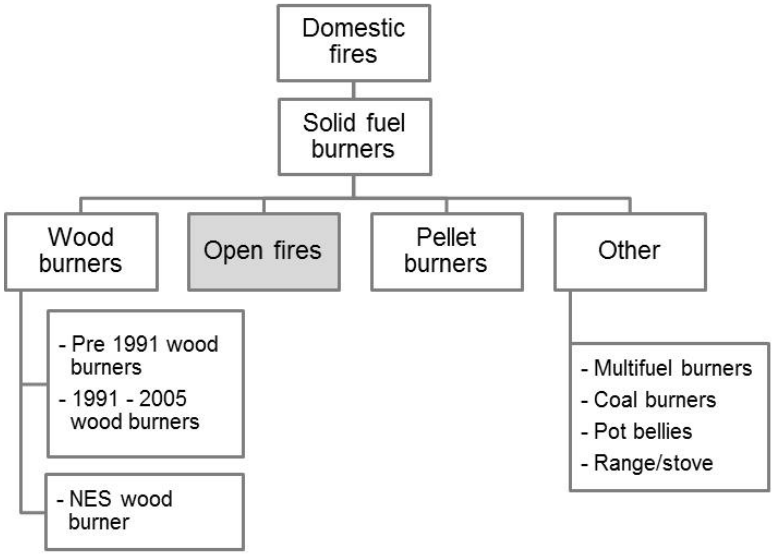


Figure 5-4: Diagram showing the types of burners affected by an open fire ban scenario (in grey)

5.4 Open fire ban projection

Projected emissions for the open fire ban scenario are shown in Figure 5-6 below. Under this scenario:

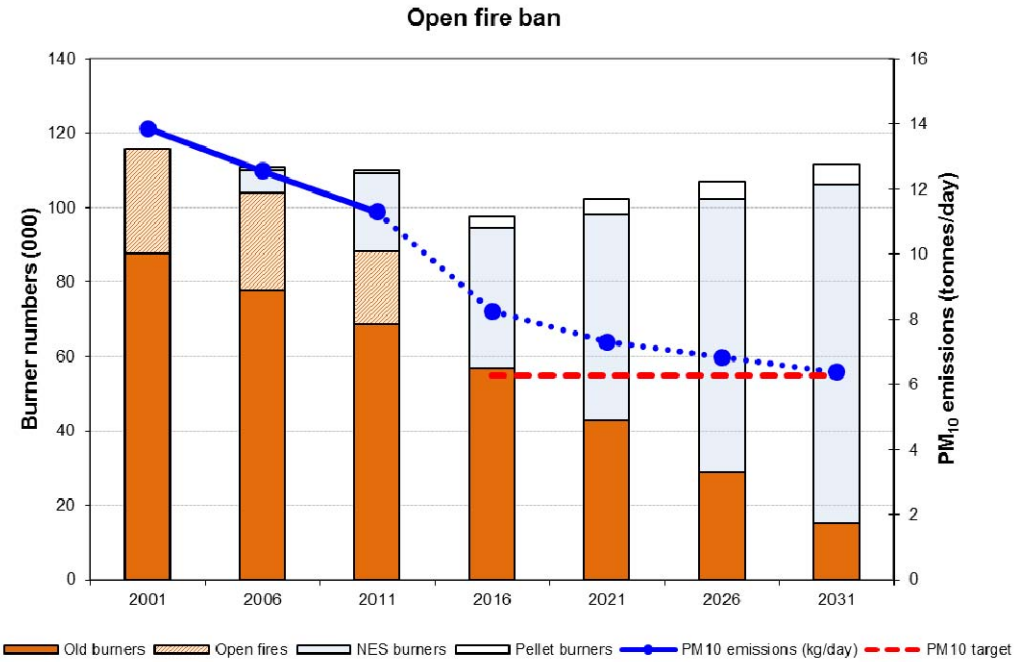


Figure 5-5: Domestic fire PM_{10} emissions for an open fire ban from 2015.

The open fire ban scenario results in the following outcomes:

- The Auckland Plan reduction target is not achieved until after 2031.
- An average emission reduction of 88 tonnes of PM_{10} per annum between 2015 and 2031, or 11%, is achieved compared with business as usual
- In 2016:
  - Winter week day PM_{10} emissions are projected to be around 8.3 tonnes per day. This is a reduction of approximately 34 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).
  - Winter week day PM_{10} emissions are 15 per cent lower compared with business as usual.

6 Evaluation of policy packages

The analysis in Section 5 shows that all of the policy options considered would result in an improvement in air quality. However, a combination of individual policy options would achieve air quality standards more quickly.

Sensitivity analysis in *Domestic Fire Emissions: Scenario Analysis* (Auckland Regional Council, 2010a) also demonstrates that a combination of policy options provides more certainty.

The following evaluation compares four packages of individual policy options against the Auckland Plan emission reduction target to meet health-based air quality standards and guidelines. It assumes that each policy package is implemented in 2015 (i.e. each policy becomes operative in 2015). It is based on the same assumptions as those outlined for each individual option in Section 5.

The policy packages are:

- Package one: No new installations except replacements and a point of sale rule for old burners only;
- Package two: No new installations except replacements and an open fire ban;
- Package three: A point of sale rule for old burners only and an open fire ban; and
- Package four: No new installations except replacements, a point of sale rule for old burners only and an open fire ban.

Table 6-1 compares the four policy packages. Table 6.2 summarises the results of the modelling as projected in 2016. Each package is discussed in detail below.

Table 6-1 Comparison of policy packages

Scenario	Average reduction in PM_{10} emissions*	Achieves 50% target	Description
Package one: Point of sale rule No new installations	37%	2020	This is an effective combination of policies because it accelerates the retirement of old burners and open fires through the point of sale rule, and also reduces the overall number of domestic fires through the "no new installations" policy. Package four is more effective, because it includes an open fire ban which would reduce the number of open fires more quickly than a point of sale rule.
Package two: No new installations Open fire ban	22%	2022	This is the least effective package because it does not accelerate the retirement of old wood burners.
Package three: Point of sale rule Open fire ban	32%	2019	The effectiveness of this package is similar to packages one and four. However, previous analysis has shown that, because this package allows the installation of new wood burners, the prediction is sensitive to assumptions. This package would be less effective If NES wood burner emission factors are higher than expected, or if emissions from NES wood burners significantly degrade over time.
Package four: Point of sale rule No new installations Open fire ban	43%	2018	Package four is the most effective package. Previous analysis has shown that predictions for this package are least sensitive to the assumptions made.

*this is the average reduction in PM_{10} emissions compared with business as usual between 2015 and 2031

Table 6-2: Summary and comparison of business as usual with the four policy packages for 2016

Scenario	2016 Winter PM_{10} (tonnes/day)	Number of burners in 2016			
		Old wood burners	Open fires	NES burners	Total burners*
Auckland Plan Target = 6.3 tonnes/day by 2016					
Business as usual	**9.7**	**56,700**	**13,100**	**37,900**	**109,200**
Package one: Point of sale rule No new installations	8.6	49,700	11,500	35,500	99,000
Package two: No new installations Open fire ban	8.1	56,700	0	34,100	93,800
Package three: Point of sale rule Open fire ban	7.5	49,700	0	39,400	92,700
Package four: Point of sale rule No new installations Open fire ban	7.3	49,700	0	35,500	88,800

* Totals presented here include the number of pellet burners, and therefore will not add up to the sum of old wood burners, open fires and NES burner numbers.

6.1 Package one: No new installations and point of sale rule

The combined effect of a no new installations policy combined with a point of sale rule for old wood burners and open fires from 2015 is shown in Figure 6-1.

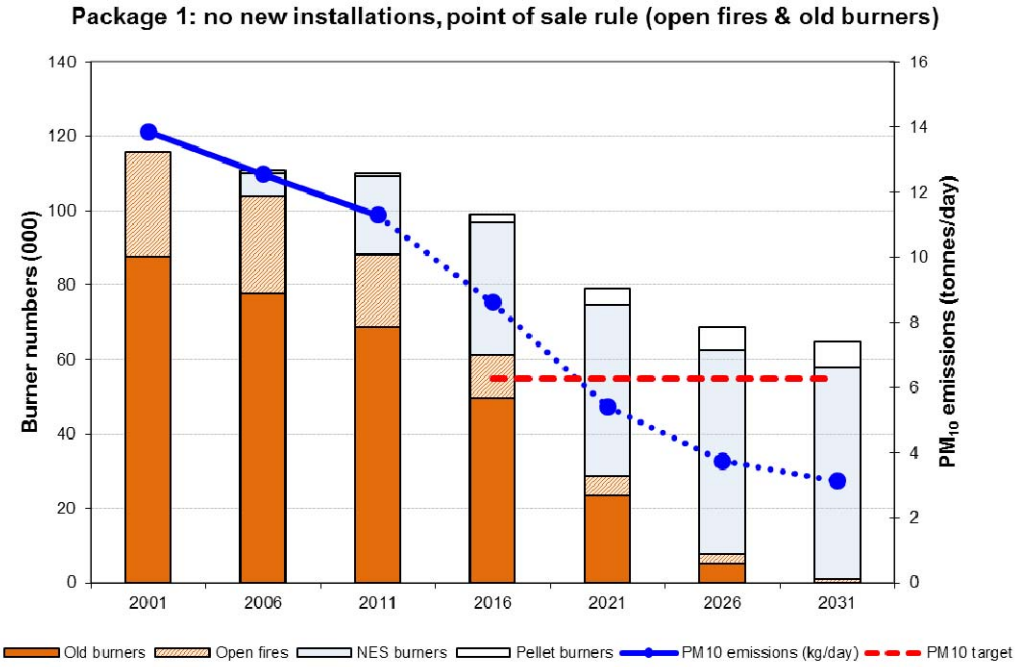


Figure 6-1: Domestic fire PM_{10} emissions for no new installations and a point of sale rule from 2015.

Under package one:

- The Auckland Plan reduction target is achieved by 2020.
- 2016 winter week day PM_{10} emissions are projected to be around 8.6 tonnes per day compared with 9.7 tonnes per day for business as usual. This is a reduction of approximately 31 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).
- 2031 winter week day PM_{10} emissions are projected to be around 3.1 tonnes per day compared with 6.8 tonnes per day for business as usual. This is a reduction of approximately 75 per cent in PM_{10} emissions from 2006 levels.
- The package results in an average emission reduction of 288 tonnes of PM_{10} per annum between 2015 and 2031 compared with business as usual. This

is a 36 per cent reduction in PM_{10} emissions compared with business as usual.

This combination of policies is effective because it accelerates the retirement of old burners and open fires through the point of sale rule, and also reduces the overall number of domestic fires through the “no new installations” policy.

6.2 Package two: No new installations and open fire ban

The combined effect a no new installations policy (except replacements) combined with an open fire ban from 2015 is shown in Figure 6-2.

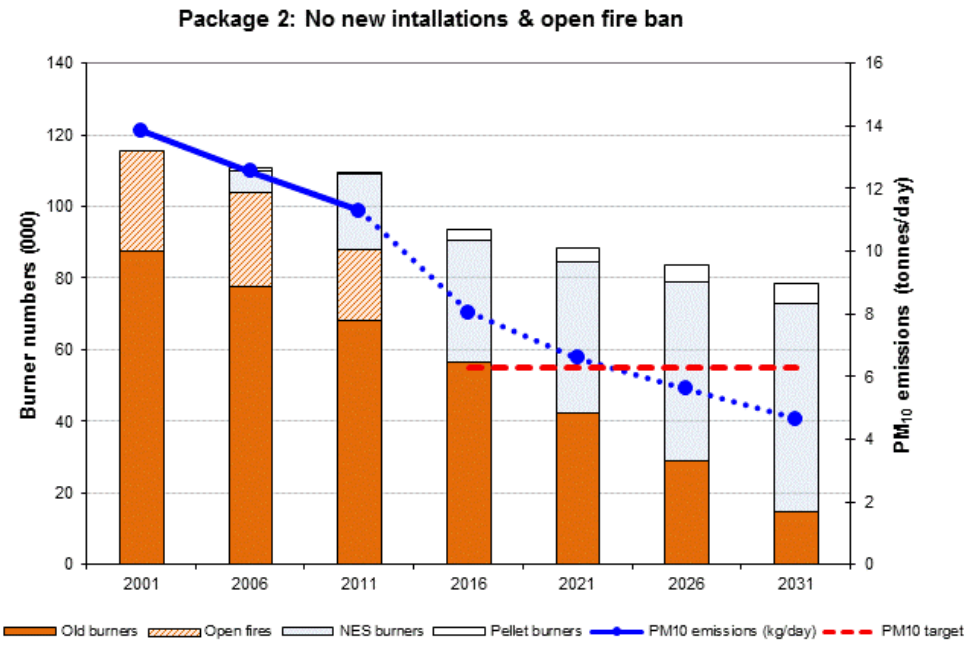


Figure 6-2 Domestic fire PM_{10} emissions for no new installations and an open fire ban from 2015.

Under this package:

- the Auckland Plan reduction target is achieved by 2022.
- 2016 winter week day PM_{10} emissions are projected to be around 8.1 tonnes per day compared with 9.7 tonnes per day for business as usual. This is a reduction of approximately 36 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).
- 2031 winter week day PM_{10} emissions are projected to be around 4.7 tonnes per day compared with 6.8 tonnes per day for business as usual. This is a reduction of approximately 63 per cent in PM_{10} emissions from 2006 levels.
- The package results in an average emission reduction of 174 tonnes of PM_{10} per annum between 2015 and 2031 compared with business as usual. This is an overall emission reduction of 22 per cent compared with business as usual.

This combination of policies is less effective than other packages because it does not accelerate the retirement of older wood burners.

6.3 Package three: Point of sale rule for old burners and open fire ban

The combined effect of a point of sale rule for old burners (only) and a ban on open fires from 2015 is shown in Figure 6-3.

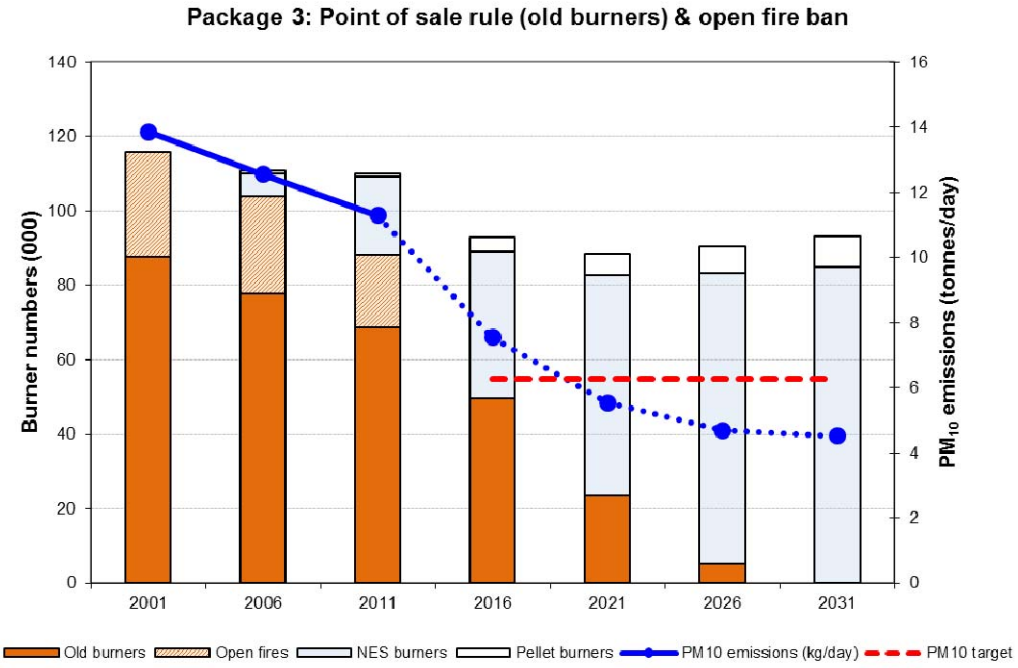


Figure 6-3: Domestic fire PM_{10} emissions for a point of sale rule (old burners) and an open fire ban from 2015.

Under this package:

- The Auckland Plan reduction target is achieved by 2019.
- 2016 winter week day PM_{10} emissions are projected to be around 7.5 tonnes per day compared with 9.7 tonnes per day for business as usual. This is a reduction of approximately 40 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent)
- 2031 winter week day PM_{10} emissions are projected to be around 4.5 tonnes per day compared with 6.8 tonnes per day for business as usual. This is a reduction of approximately 64 per cent in PM_{10} emissions from 2006 levels.
- The package results in an average emission reduction of 256 tonnes of PM_{10} per annum between 2015 and 2031 compared with business as usual. This

is an overall emission reduction of 32 per cent compared with business as usual.

This is an effective combination of policies. However, new burner installations are allowed, so it is expected that the total number of wood burners in the region will be higher under this package compared with other packages.

Sensitivity analysis in *Domestic Fire Emissions: Scenario Analysis* (Auckland Regional Council, 2010a) demonstrates that this package is sensitive to assumptions made because new burner installations are allowed.

6.4 Package four: No new installations, point of sale rule for old burners and open fire ban

The combined effect of no new installations except replacements, a point of sale rule for old burners (only) and an open fire ban from 2015 is shown in Figure 6-4.

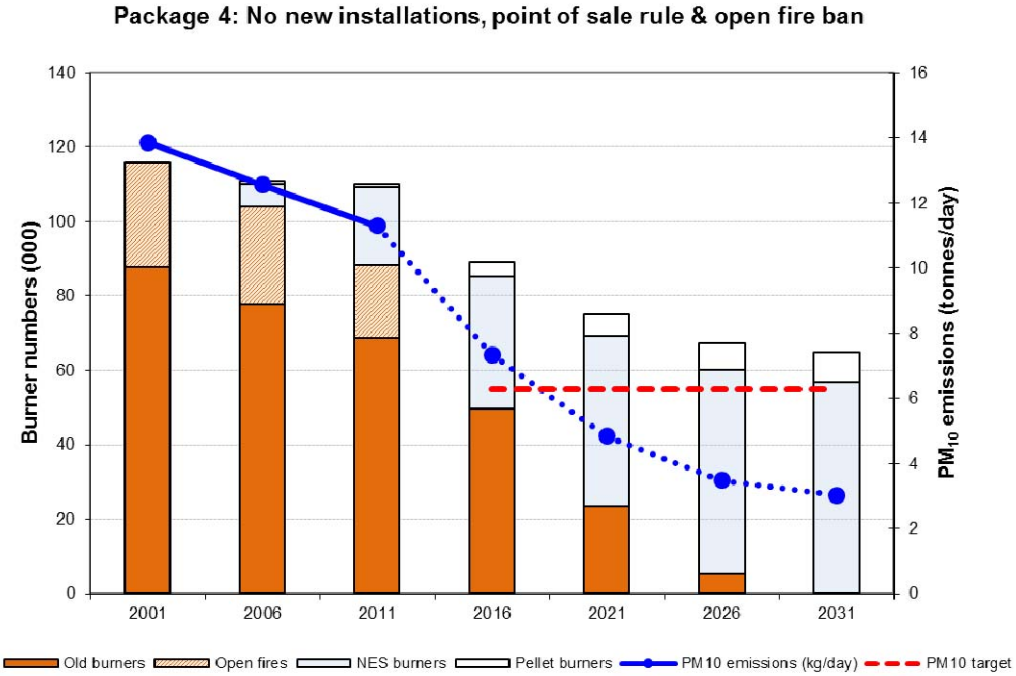


Figure 6-4 Domestic fire PM_{10} emissions for no new installations except for replacements, a point of sale rule for old burners and an open fire ban from 2015.

Under this package:

- the Auckland Plan reduction target is achieved by 2018.

- 2016 winter week day PM_{10} emissions are project to be around 7.3 tonnes per day compared with 9.7 tonnes per day for business as usual. This is a reduction of approximately 42 per cent in PM_{10} emissions from 2006 levels (Auckland Plan target = 50 per cent).
- 2031 winter week day PM_{10} emissions are projected to be around 3.0 tonnes per day compared with 6.8 tonnes per day for business as usual. This is a reduction of approximately 76 per cent in PM_{10} emissions from 2006 levels.
- The package results in an average emission reduction of 345 tonnes of PM_{10} per annum between 2015 and 2031 compared with business as usual. This is an overall emission reduction of 43 per cent compared with business as usual.

This is the most effective combination of policies and can achieve the reduction target quickly depending upon the assumptions made.

7 Discussion

The policy options for reduction of emissions from domestic fires are briefly discussed in this section.

7.1 Point of sale rule

The analysis shows that a point of sale rule to accelerate the retirement of old wood burners is the most effective individual policy option considered.

An alternative approach not considered in this report that has been used by other councils is the progressive restriction on the use of older burners. For example, in 2003 Nelson City Council proposed a ban on the use of pre-1996 burners to take effect in seven years time (2010). (The plan was made operative in 2008 and old wood burners duly banned from 1 January 2010).

However, the advantage of a point of sale rule is that the cost of the upgrade can be accommodated with relative ease as part of the house purchase (i.e. the cost of a new burner or heat pump is not significant in comparison with the average cost of a house in Auckland).

The point of sale approach is promoted by the Ministry for the Environment as best practice for managing domestic emissions to air (Ministry for the Environment, 2009). It has been adopted in three other airsheds around the country to date; Richmond, Hastings and Rotorua airsheds, each of which are discussed in turn below.

Tasman District Council was the first council in New Zealand to introduce a point of sale rule for solid fuel burners for the Richmond airshed in 2007. The point of sale rule is applied through the regional plan and prohibits discharges to air from a wood burner unless it complies with the national environmental standards for air quality. Notably, the prohibition on discharge means either the seller or the purchaser may upgrade the burner. The Tasman rule excludes solid fuel burners used for the primary purpose of cooking or any kiln or forge.

Hawke's Bay Regional Council similarly introduced a point of sale rule in their regional plan for the Hastings airshed that took effect on 1 January 2012. The rule states that from January 1st 2012, any non-compliant wood burner not meeting emission standards in the Airzone 1 is prohibited from use after ownership of the property is transferred. A transfer of ownership includes the sale of a house or transfer of a property into a trust, but does not apply in the

event of death of a partner, or when the surviving partner continues to occupy the property.

The Bay of Plenty Regional Council cooperated with Rotorua District Council to enact a bylaw to give effect to a point of sale rule. This provides that from 1 May 2012, a property cannot be sold if it has a burner that is not clean air approved. Burners need to be removed or decommissioned before the property is sold.

7.2 Open fire ban

Open fires accounted for almost 20 per cent of winter daily PM_{10} emissions in 2012 (approximately two tonnes per winter weekday) from domestic fires in the Auckland region (Auckland Council, 2012a). Open fires are inefficient and produce very high levels of emissions compared to the amount of heat that is generated. Phasing out open fires is likely therefore, to be highly effective in reducing PM_{10} emissions.

A prohibition on the use of open fires may reduce emissions more quickly than a point of sale rule for open fires. Analysis shows that an open fire ban combined with a point of sale rule for old burners (package 3) could achieve the 50% emission reduction target within four years of implementation.

Modelling the open fire ban scenario assumes that all open fires in the region will cease to be used once the rule is implemented (i.e. perfect and complete implementation of the ban). However, in reality a staged introduction may be more practical. For example, Nelson City Council provided five years before a ban on the use of open fires took effect. A delayed or staged introduction provides permits better public awareness and gives people time to upgrade or use alternative heating.

To be effective any open fire regulation is likely to require significant education and compliance support.

7.3 No new installations

Analysis shows that restriction of the installation of new wood burners would deliver long term benefits through gradual reduction in the number of domestic fires in the region. The most popular approach to date (e.g. Nelson, Christchurch, Hawke's Bay, Rotorua) is a restriction that allows no new installations of wood burners except to replace existing wood burners or open

fires. Analysis of this option in this report shows it to be an effective emissions reduction tool when used in combination with other policies.

Without a "no new installations" policy, there is a risk that wood burner numbers could increase, or at least remain stable. This means that predicted emission reductions depend on the effectivencess of NES wood burner emission standards.

7.4 Retrofit programmes

The effect of retrofit or other funding programmes has not been specifically modelled in this report because the likely effectiveness would be difficult to quantify in isolation from other policies.

Survey results indicate that 13 per cent of the households in the region have an unused old burner or open fire, which equates to approximately 64,000 old burners or open fires. The results also indicate that 18 per cent of survey respondents are considering changing to another type of home heating in the next few years (Auckland Council, 2013). This translates to almost 87,000 households in the region that are looking to upgrade from their current form of home heating.

In the Auckland region, there are approximately 3,700 retirements of old burners or open fires per annum. It is difficult therefore, to predict the effectiveness of a stand-alone incentive policy because a significant part of these could be households that currently have unused old burners or open fires, or by households that are intending to change their form of home heating anyway.

Incentives to replace open fires or old wood burners (such as financial incentives) could be incorporated into a policy package in order to make it more affordable. However, for this to be effective, it is likely that the policy package will also need to include some form of regulation.

Section 3.4 outlines incentive programmes in place for retrofitting insulation. In addition to these, there are a number of programmes available to improve heating in homes in the Auckland region. These are briefly described below.

- "Retrofit Your Home" programme targets houses that were built before 2000 and meet certain additional criteria.[14] Up to $5,000 in financial assistance is available through Auckland Council and this assistance is repaid over nine years through a targeted rate included in the rates bill. This programme was

[14] See Auckland Council website for further details: http://www.aucklandcouncil.govt.nz/EN/ratesbuildingproperty/homeimprovementprojects/retrofit/Pages/home.aspx

piloted between July 2011 and June 2012, and the council has committed to retrofitting 5,000 homes by 2021 under the Long Term Plan (Auckland Council, 2012d). In the six months from July 2012 to January 2013, just over 1,900 homes received financial assistance from the council to improve either home insulation and/or upgrade to cleaner forms of heating.[15]

- The Energy Efficiency and Conservation Authority (EECA) "Energywise" programme provides a range of options to assist with insulation and cleaner home heating:
  - "Warm Up NZ: Heat Smart" is an insulation and home heating upgrade programme that started in July 2009. Funding for the heating component of the programme ceased in 2012. Around 7,500 homes in Auckland have had their heating upgraded between July 2009 and December 2011 under this programme.[16]
  - "Clean Air Grants" have been available in Auckland since September 2011 and targets houses in polluted airsheds to help replace inefficient wood burners or open fires with new efficient heating alternatives. Only homes within the Auckland airshed are currently eligible for these grants. Under this programme, 233 homes have been retrofitted with cleaner heating options.[17]

The impact of these retrofit programmes on domestic heating emissions is addressed through business as usual. This is because business as usual incorporates updated information from the 2012 Home Heating Survey (Auckland Council, 2013).

A combination of the above mentioned schemes and programmes, along with a policy package, could make a significant impact on reducing emissions from domestic fires.

7.5 Education and other policy options

As discussed in Section 3, education and other policy options should be considered as part of any policy package. However, quantifying their impacts is very difficult. These have not been specifically addressed in this report as a stand-alone scenario.

[15] Personal comm. D Hill, Auckland Council, 26 February 2013.
[16] Personal comm. B Woodham, EECA, 1 March 2013.
[17] Personal comm. B Woodham, EECA, 26 February 2013.

7.6 Domestic fire policy packages

As a result of combining policy initiatives, other regions have seen significant improvements in ambient air quality. Nelson, which has included most of the above policy options in its regional plan, shows a dramatic improvement in air quality as evident in Figure 7-1.

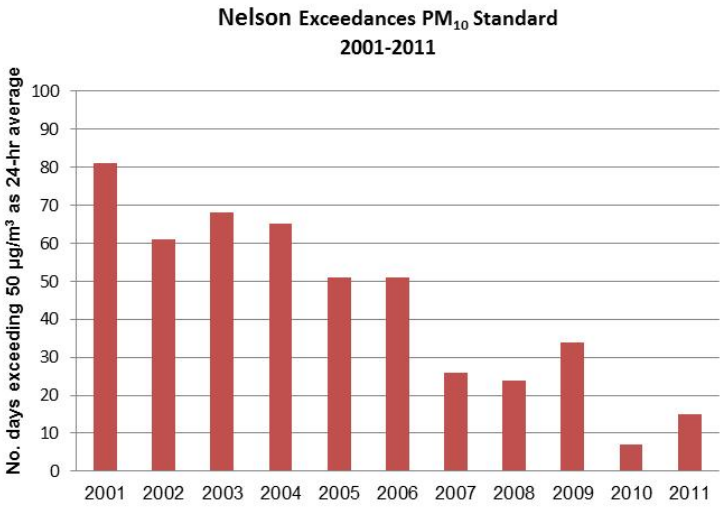


Figure 7-1: Impact of wood burner policy on exceedances of the PM_{10} standard in Nelson[18]

Emissions reductions will be most effectively achieved by a combination of policies that reduce the total number of solid fuel burners in the airshed and accelerate the conversion of old inefficient domestic fires to cleaner alternatives such as pellet burners.

7.7 Co-benefits

There is an opportunity to implement these policies in conjunction with insulation projects to deliver maximum benefits. Best practice air quality management for domestic emissions includes strategies that:

- regulate or influence fuel quality
- encourage good wood burner operation and flue maintenance
- educate manufacturers, retailers, installers and the general public
- partner with key stakeholders (e.g. a “good wood scheme”).

[18] Source: Nelson City Council.

8 Conclusions

This study quantitatively assesses a range of policy options to reduce emissions of PM_{10} from domestic heating in Auckland, and compares them with the Auckland Plan target to reduce PM_{10} emissions from domestic heating by 50 per cent by 2016 (compared with 2006 levels, Auckland Council 2012c).

Policy options are compared with a business as usual base case and assessed in terms of how much (emission reductions) and how long (time) to effect change. The analysis is based on the assumption that all policies are introduced in 2015.

Table 8-1 shows the date when each policy, or policy package, is predicted to achieve the 50% emission reduction target. The table also shows the average emission reduction between 2015 and 2031 compared with business as usual.

Table 8-1: Summary and comparison of business as usual with the four policy packages for 2016

Scenario	Average reduction in PM_{10} emissions*	Achieves 50% Target
Point of sale rule (old burners and open fires)	25%	2021
No new installations	11%	2026
Open fire ban	11%	After 2031
Package one: Point of sale rule No new installations	36%	2020
Package two: No new installations Open fire ban	22%	2022
Package three: Point of sale rule Open fire ban	32%	2019
Package four: Point of sale rule No new installations Open fire ban	43%	2018

The analysis shows that all of the options considered would reduce emissions of PM_{10} compared with business as usual, however none of the options would achieve compliance with the Auckland Plan emission reduction target of 50 per cent by 2016.

The analysis shows that package four would achieve the emission reduction target most quickly and deliver the greatest emission reduction. Package four is a combination of all of the policy options considered and is effective because it includes:

- A point of sale rule to accelerate the retirement of old wood burners;
- An open fire ban, which eliminates emissions from open fires from the date of implementation, so is more effective than a point of sale rule for open fires; and
- A no new installations policy, which gradually reduces the total number of domestic fires in the region.

This analysis assumes that all policies are introduced in 2015. The analysis also assumes perfect and complete implementation of the policy options under consideration. This is unlikely to be practical or realistic, but is appropriate for comparative modelling.

In reality, emission reductions could be substantially slower than the predictions. Previous analysis showed that the predictions are sensitive to the assumptions made (Auckland Regional Council 2010a). This analysis showed that emission reductions could be two or three times slower than predicted, depending on the assumptions made.

The following important limitations should also be noted:

- All conclusions assume that the rules in the existing regional plan (i.e. emission limit of 4.0 grams of particulate for every kilogram of fuel burnt) remain in place.
- The policy options and packages considered are intended as a starting point for policy development. Projections may need to be updated or refined. For example, a point of sale rule for 'old burners' introduced in 2015 will, by definition, include burners only 10 years old. This may not be cost effective.

This analysis is limited to emission reductions only. Additional analyses of the associated social and economic costs and benefits of the policies in question needs to be undertaken.

The conclusions of this study are consistent with the results of the previous *Domestic Fire Emissions: Scenario analysis* report published by the Auckland Regional Council in 2010 (Auckland Regional Council, 2010a).

9 References

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10 Glossary

Terms	Description
Airshed	A geographic area established to manage air pollution within the area as defined by the AQNES
NES	National Environmental Standards
BAU	Business as usual
DFEPM	Domestic fire emissions prediction model
Domestic fire	Any indoor fire in a place of residence used for heating space, water or cooking (such as wood burners, pellet burners, open fires, multifuel burners, coal burners, wood or coal range/stoves).
Multifuel burner	A fully enclosed domestic heating device that is designed for burning coal as well as wood
NES wood burner	A wood burner that complies with the design standard for new wood burners specified by the national environmental standards for air quality
Open fire	An indoor heating device capable of burning wood or coal, including fireplaces, open hearths and visors. Excludes enclosed heating devices such as wood burners, potbelly stoves and the like.
Pellet burner	An indoor heating device 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.
PM_{10}	Fine particles less than 10 micrometres in diameter, a type of air pollutant
RMA	Resource Management Act
Solid fuel burner	Any domestic fire that can burn sold fuels including coal, wood, paper or carbonettes.
Wood burner	A fully enclosed domestic heating device designed for burning wood as defined in the national environmental standards for air quality.

Appendix 1: Comparison with previous projections

This appendix provides a comparison of the updated projections, with the projections in *Domestic Fire Emissions: Scenario Analysis* (Auckland Regional Council, 2010a).

As outlined in previous sections of this report, the methodology and most of the assumptions in this report are consistent with the previous report. The only change to business as usual is that expected trends in the types of domestic fires have been updated based on the 2012 home heating survey.

Table A1-1: Summary of current estimates and projections

year	Winter PM_{10} (tonnes/day)	Number of domestic fires			
		Old wood burners	Open fires	NES burners	Total burners
current estimates and projections (this report)					
2006 (2007 survey)	12.5	77,600	26,300	6,150	110,000
2012 (2012 survey)	11	67,000	18,000	24,000	110,000
2016 (projection)	9.7	56,700	13,100	37,900	109,200
2031 (projection)	6.8	15,000	3,600	90,900	113,700

Table A1-2: Summary of previous estimates and projections

year	Winter PM_{10} (tonnes/day)	Number of domestic fires			
		Old wood burners	Open fires	NES burners	Total burners
previous estimates and projections (Auckland Regional Council, 2010a)					
2006 (2007 survey)	12.5	77,600	26,300	6,150	110,000
2012 (projection)	9.7	52,000	20,800	29,000	103,300
2016 (projection)	8.4	35,300	18,200	44,600	100,500
2031 (projection)	6.1	2,400	13,200	75,600	96,300

Comparison of the results in Table A1-1 and Table A1-2 shows that the number of open fires has dropped significantly between 2006 and 2012. The reduction in open fires over this period is more than the reduction that was predicted based on the difference between 2001 and 2006 burner numbers. This could be due to the success of retrofit programmes, and a general increase in awareness that open fires are not an efficient heating option.

The 2012 survey results show that the rate of removal of old burners, and the rate of installation of new burners is lower than was expected based on the difference between 2001 and 2006 burner numbers. This could be due to a slow-down in the economy, or it could simply be due to the relatively high margin of error in the breakdown of burner types.

Domestic Fire Emissions: Scenario Analysis (Auckland Regional Council, 2010a) concluded that there is significant uncertainty in the rate of retirement of old burners and the rate of installation of new burners. This uncertainty needs to be recognised in the development of any policy. The business as usual projection is intended to estimate future emissions based on the best available information, which provides a basis for cost benefit analysis of policy options. However, the rate of reduction in emissions under business as usual could be significantly slower, or faster, than predicted.