Report on:

Solid Fuel Burner Testing and Standards to be Considered Within Proposed Amendments to National Environmental Standards for Air Quality

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Ministry for the Environment

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Executive Summary

The Ministry for the Environment is currently considering proposed amendments to the National Environmental Standards for Air Quality (NESAQ). These proposed amendments include:

- Reducing the allowable level of emissions from solid fuel burners from 1.5 g/kg to 1.0 g/kg.
- Broadening the range of solid fuel burners covered by the NESAQ to include all domestic solid-fuel burners such as coal burners, multi-fuel burners, pellet fires, open fires, cookers, and water boilers.
- Maintaining the minimum thermal efficiency standard at 65%.

This document reports on issues related to these proposed amendments including test methods and standards, changes in solid fuel burner technologies, secondary emission reduction devices and a number of other related issues.

Reducing the national level of allowable emissions to 1.0 g/kg and including pellet fires and domestic boiler systems within the NESAQ will have little or no impact on the range of burners available. The vast majority of these burner types already meet a 1.0 g/kg standard and 65% efficiency.

Adding multi-fuel burners, coal burners, solid fuel cookers and open fires to the NESAQ will effectively remove all of these burner types from the market as they will not currently be able to meet 1.0 g/kg emissions and/or 65% efficiency. Consideration could be given as to whether these burner types may be better dealt with at a regional level. In some cases, e.g. cookers, the impact on air quality will be small as the volumes are very small. With coal burners and multi-fuel burners, households in some communities rely on coal for economical heating and there will be capital and operating cost consequences if a change is required.

A secondary emission reduction device (the OekoTube) has recently been authorised by Environment Canterbury on the basis that it will reduce emissions by at least 2/3. Such devices offer potential to be a useful tool in reducing emissions from existing solid fuel burners generally and may be a solution to reducing emissions in specific situations such as open fires in heritage homes, or in certain communities where coal burning is still a preferred option.

Consideration should be given to a slight relaxation of the minimum efficiency standard, in conjunction with a lower emissions limit, as this will potentially allow cleaner burners to be available. It will also help to provide a solution to the current difficulty in designing an ultra-low emission insert burner that meets the efficiency threshold. This could be achieved by specifying an allowable combined emissions and efficiency threshold of 77 mg/MJ of useful heat output <u>and</u> a maximum emissions of 1.0 g/kg <u>and</u> a minimum efficiency of 60%, all based on test results to AS/NZS 4012: Domestic solid fuel burning appliances – method for determination of power output and efficiency and AS/NZS 4013: Domestic solid fuel burning appliances – method for determination of flue gas emission. Allowing clean burners in the 60 to 65% efficiency range will have minimal negative impact, yet potentially allow the production and authorisation of some very clean burners that would otherwise not be available.

Regional councils should retain their right to develop more stringent rules than those defined in the NESAQ so that they can introduce initiatives designed to address their particular local issues. Regional councils should be encouraged to collaborate on local initiatives so as to reduce the current situation of varying standards in different regions that can be challenging for industry to deal with. Environment Canterbury has invested heavily in the ultra-low emission burner (ULEB) concept which is now also recognised in some other regions. One option would be for other airshed areas to adopt the ULEB standard. Alternatively, a tougher (than the NESAQ) emissions standard based on AS/NZS 4013 testing could be proposed as a general standard for airshed regions to adopt. For example, this could be 0.60 g/kg as used in Rotorua or 0.7 g/kg

as used in some Otago towns. The difference in real life performance between choosing either the Rotorua or Otago standards would be minimal.

The proposed amendments to the NESAQ should be worded in such a way that there is a process to follow for testing all current and potential future burner types. Specifically, this should state that if a burner can't be tested to AS/NZS 4012 and AS/NZS 4013 then a recognised, relevant test method can be substituted if agreed by the authorising agency and supported by advice from a suitably qualified, independent technical advisor and/or an accredited testing laboratory.

While the Canterbury Method of testing (CM1) in conjunction with the development of ULEBs has proven useful in Canterbury and has led to the development of significantly cleaner burners, there will be numerous issues in turning this into a nationally acceptable test method. It may be better to consider whether capturing start-up emissions during AS/NZS 4013 testing could be added to that test method for the purposes of calculating an emissions result that is more representative of real life emissions.

AS/NZS 4012 and AS/NZS 4013 should continue to be the preferred test method for solid fuel burners that can be physically tested to that method. Functionally equivalent methods can be allowed for other burner types e.g. boiler systems.

Pellet fires are currently authorised based on EN 14785 test results. This should be allowed to continue, rather than requiring additional testing to the NZ pellet fire standards.

Real life trials of ULEBs have been carried out on two twin chamber downdraught ULEB designs to determine how they perform in real life. Results show that burners that are cleaner based on laboratory testing are also cleaner in real life operation. Now that single chamber ULEBs are available and are likely to become the more popular ULEB choice, it may be useful to conduct a real life trial of one or more single chamber ULEBs to see how they perform in real life.

Burner authorising agencies should have the capability to impose consent conditions as they see fit when authorising burners. In particular, this includes specifying that mains powered electric air circulation fans should be hard wired into a home's electricity supply. It is noted though, that if the efficiency threshold is lowered for particularly clean burners, then this may reduce the need to incorporate such fans.

There is no collation of solid fuel burner installation data at a national level and it would be useful if this could be done. This would involve setting up a process whereby Territorial Authorities submit data on burner installations to an agreed format, capturing specific information, particularly the burner make, model, resource consent number and date of installation. This information would be useful for gaining an understanding of the nature of burner installations and trends nationally, as well as regionally, which would help with air quality management.

1. Introduction

1.1 Objective

The purpose of this report is to address a variety of issues related to the test methods and standards that will need to be in place to ensure that solid fuel burners can be tested to provide reliable data on emissions and efficiency that are in alignment with the proposed amendments to the National Environmental Standards for Air Quality (NESAQ).

1.2 Background

The current NESAQ was established in 2004. It was revised in 2011 addressing three problems that had been identified with the air quality standards that required review, namely:

- Equity with respect to compliance costs
- Perceived stringency of the PM_{10} standard
- Target compliance date of 2013.

Proposed amendments to the NESAQ are now being considered and a consultation document is about to be published seeking feedback and answers to specific questions from stakeholders and interested parties.

There have been many changes in solid fuel burners since the NESAQ was originally published. New types of models have been developed and older models phased out. Levels of particulate emissions from new solid fuel burners have decreased considerably over that time. Regional councils with polluted airsheds have implemented a range of different subsidy and incentive schemes and tightened regulations as to the level of emissions from new burners that can be installed in their airsheds. Manufacturers have responded to these changes and market opportunities by developing or importing burners that are cleaner burning.

The Australasian standards for measuring efficiency and emissions (AS/NZS 4012: Domestic solid fuel burning appliances – method for determination of power output and efficiency and AS/NZS 4013: Domestic solid fuel burning appliances – method for determination of flue gas emission respectively) were updated in 2014. Additionally Environment Canterbury has developed its own real life testing methodology and conceived a new category of woodburner, the ultra-low emission woodburner (ULEB), as part of their efforts to improve air quality in Canterbury.

This document compiles research and investigations on numerous issues related to the test methods and standards that will need to be addressed as part of the consideration of proposed amendments to the NESAQ.

1.3 Approach to this work

A pragmatic approach has been taken to this work. The analysis and commentary has been prepared with a view to how national and local air quality objectives can be met in a practical and effective way while minimising unnecessary disruption to the activities of those in the industry or to homeowners. Recommendations for changes to be considered have been made with the intention of avoiding situations that would deliver very little in the way of air quality improvement but may potentially introduce unintended negative consequences.

1.4 Issues addressed in this document

In order to meet the overall objectives of the research incorporated within this document, a number of questions and issues are to be addressed and these were agreed in consultation with Ministry for the Environment. Given that some of these issues overlapped, the structure of this report does not work through these issues one by one. Rather, some groupings have been made. The following table shows the original issues to be addressed and where the discussion appears in this document.

Table 1: Issues to be Addressed

	Issues to be addressed	Report section reference(s)
1.	Brief overview of the current requirements and standards	3.1, 3.2, 3.3
2.	Discuss different options that may be available and their pros and cons etc including: • International standards • Environment Canterbury's Canterbury method (CM1) • Potential changes to AS/NZS 4012 and 4013	3.9
3.	Ensure all current and likely future solid fuel burner types will be included within the scope of an amended NESAQ	3.8
4.	Ensure all current and likely future solid fuel burner types will be included in a testing regime	3.8
5.	Address any conflicts or circularities between standards, NESAQ etc	3.8
6.	Real life testing (CM1) vs laboratory testing (AS/NZS 4012/4013), noting key differences, pros and cons etc.	3.10
7.	Real life emissions from solid fuel burners vs their laboratory test results and trends over time	3.10
8.	Issues that would be associated with any move away from the status quo on a national basis, e.g. moving to real life emissions testing	3.6, 3.7

9.	Measurement of efficiency	3.4, 3.7
10.	Use of g/kg and % efficiency vs a combined measure (mg/MJ)	3.7.1
11.	Advice on the appropriateness and workability of allowing secondary emissions reduction devices through the NES.	3.11
12.	Market trends in terms of efficiency and emissions improvements, new technologies, price trends etc.	3.4, 3.13
13.	Design “trade-offs” made by manufacturers between emissions and efficiency when designing new burners.	3.5
14.	The use of air circulation fans to lift efficiency to the NESAQ standard and issues associated with these fans.	3.12
15.	The potential impact of decisions on emissions and efficiency on various technology types e.g. insert burners, or the impact on households and regions.	3.6, 3.7.1
16.	Collating any readily available sales data and trends on solid fuel burners, excluding direct liaison with territorial authorities.	3.13

2. Methodology

The methodology for this work comprised the following tasks:

- Preliminary meetings and discussions with Ministry for the Environment staff.
- Reviewing various documentation and data related to the design, testing, authorisation and operation of solid fuel burners.
- Holding meetings and telephone conversations with people experienced in various aspects related to the NESAQ including a selection of Regional Council staff, manufacturers, test laboratories and technical experts that are knowledgeable about the relevant issues.
- Analysing the information gained from the interviews.
- Considering options for test methods, standards and related issues that will most effectively align with the proposed NESAQ objectives.
- Producing a written report on the observations, issues and analysis and identifying changes for consideration that address the objective of this work.

Those that were spoken to in the course of this work are listed in the following table:

Table 2: List of People Contacted

Organisation	Individuals	Nature of Person/Organisation
Applied Research Services	Wayne Webley	Testing laboratory
Bay of Plenty Regional Council	Marion Henton	Regional council
E Energy	Andrew Wilson	Heating retailer
Environment Canterbury	Clare Pattison, Tim Mallett, Mark Bourassa and Paul Hopwood	Regional council
Glen Dimplex	Prakash Sonar	Burner manufacturer
Harris Home Fires	Richard Harris	Burner manufacturer
NZ Home Heating Association	Mike Chilton	Solid fuel burner industry organisation
Pattle Delamore Partners	Steve Pearce	Combustion technical expert
Pioneer Manufacturing	Neil Tapsell	Burner manufacturer
Spectrum Laboratories	Philip Sparrow	Testing laboratory

The assistance and contribution of all people interviewed is acknowledged and appreciated.

3. *Analysis of Issues*

3.1 Current NESAQ Regulations

The current National Environmental Standards for Air Quality (NESAQ) were introduced in 2004 and were last amended in 2011. They specify the following requirements that must be met for woodburners to be installed in homes on sites of less than 2 hectares:

- An emissions factor not exceeding 1.5g/kg of fuel burnt, based on testing to Australian New Zealand Standard AS/NZS 4013: Domestic solid fuel burning appliances – method for determination of flue gas emission.
- A thermal efficiency of not less than 65% based on the ratio of usable heat energy output to energy input from testing to Australian New Zealand Standard AS/NZS 4012: Domestic solid fuel burning appliances – method for determination of power output and efficiency.

The NESAQ allows the use of a functionally equivalent test method for burner types that are excluded from AS/NZS 4012 and AS/NZS 4013, such as central heating appliances.

A woodburner is defined in the NESAQ as a domestic heating appliance that burns wood; but does not include:

- an open fire; or
- a multifuel heater, a pellet heater, or a coal burning heater; or
- a stove that is designed and used for cooking; and heated by burning wood.

Allowable emission levels defined in the NESAQ and its predecessors have been steadily reduced over time as part of initiatives to improve air quality. National particulates emission limits as determined by testing to AS/NZS 4013 and prior test standards have been as follows:

Table 3: Allowable Emissions Levels

Year	Allowable emissions
1992	5.5 g/kg
1999	4 g/kg
2004	1.5 g/kg
2020 (proposed)	1.0 g/kg

In addition to the standards specified in the NESAQ, various Regional Councils around NZ have established a variety of their own more stringent rules in order to help address their respective air quality obligations and concerns. These are shown in the following table:

Table 4: Regional Emissions Limits

Region	Maximum allowable emissions	Comments
Alexandra, Arrowtown, Clyde and Cromwell	0.7 g/kg	Based on testing to AS/NZS 4013
Canterbury airshed towns and cities except Geraldine and Waimate	0.5 g/kg	Based on real life (CM1) testing
Canterbury – other locations on site <2ha	1.0 g/kg	Based on testing to AS/NZS 4013
Hastings airshed	1.0 g/kg	For models without wetback; Based on testing to AS/NZS 4013
Nelson urban area	0.5 g/kg	Based on real life (CM1) testing
Rotorua airshed	0.60 g/kg	Based on testing to AS/NZS 4013

Any rules established by regional councils cannot be less stringent than the NESAQ, and all conditions of the NESAQ must be met throughout NZ.

3.2 Current test methods and standards

Standards AS/NZS 4012 and AS/NZS 4013 apply to domestic solid fuel burning appliances such as woodburners, but specifically exclude:

- Site-built masonry appliances
- Central heating appliances
- Cooking appliances
- Appliances intended solely for water heating
- Appliances intended solely to distribute convective heat via ducting to locations remote from the appliance
- Appliances that when fired at the high burn rate prescribed in the Standards have a maximum carbon dioxide output from the combustion chamber of less than 5% by volume with any optional doors fitted and closed
- Appliances with volumetric flow rates through the combustion chamber which are too high to allow for total smoke capture by the method described in the Standards. (excluded from AS/NZS 4013 only)

AS/NZS 4012 and AS/NZS 4013 were last updated in 2014. Prior to that, these standards were updated in 1999. Changes made in 2014 include:

- Changes to the use of fans during testing (noting that for appliances with fans, the fan should be in position and operating with controls set to the maximum rate; and automatic fan control shall operate during tests).
- Measurement of heat collected for hot water has been included in efficiency measurement
- A method for measuring heat collected by water heating facilities has been included (as an appendix).
- Minimum efficiency requirements have been included. This references Regulation 24 of the NESAQ which states that all woodburner appliances installed on properties less than 2 hectares in size must have a thermal efficiency of not less than 65%.

It is understood that the reference in the standard to minimum efficiency was done primarily for the benefit of Australia where the regulations don't refer to an efficiency standard.

While the standards are Australasian, there are some differences in the way they are applied in NZ and Australia. For example, hardwood is used in woodburners in Australia and the standard calls for hardwood for testing burners in Australia. The standard references a minimum efficiency requirement of 65% for NZ and 60% for Australia.

It is important to note that AS/NZS 4012 and AS/NZS 4013 are not designed for the purpose of making an accurate assessment of what the actual emissions of a particular burner will be when used in the home. Laboratory testing to AS/NZS 4012 and AS/NZS 4013 uses kiln dried test firewood and excludes the relatively dirty period of start-up emissions. Real life emissions will be several times higher than emissions recorded from laboratory testing to AS/NZS 4013, and this is discussed in more detail in section 3.10.

The main purpose of AS/NZS 4012 and AS/NZS 4013 is to define a rigorous procedure for producing reliable, repeatable results from testing so as allow the comparison of the emissions and efficiency performance across all burners and against an allowable limit defined in the NESAQ and by some Regional Councils' Air Plans.

The majority of woodburners sold in NZ are tested in NZ to AS/NZS 4012 and AS/NZS 4013.

Specific categories of solid fuel burners that are included in the NESAQ but excluded from AS/NZS 4012 and AS/NZS 4013, such as small scale boiler systems, are typically tested overseas to international standard test methods as allowed under the functional equivalent clause in the NESAQ. For example, the Froling and ETA ranges of wood fired gasification boilers were tested to EN 303-5:2012 "Heating boilers. Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW. Terminology, requirements, testing and marking".

Pellet fires are not currently included under the NESAQ, but are to be included in the proposed amendments to the NESAQ. There are Australian and NZ standards for the measurement of emissions and efficiency from pellet fires, AS/NZS 4886:2007 and AS/NZS 5078:2007 respectively. However, as all pellet fires are currently sourced from overseas, they are tested overseas to the functionally equivalent European standard EN 14785: 2006 Residential Space Heating Appliances Fired By Wood Pellets - Requirements And Test Methods. This test data is then used to support applications for authorisation.

The NZ standards are now 12 years old and a committee has been formed to review them. However, as no testing has been done in NZ to these standards for several years now, nor is it likely in the foreseeable future, there is little appetite to review these NZ standards.

3.3 Burner authorisation

Requirements and guidelines for the authorisation of solid fuel burners are provided in the Ministry for the Environment publication NZ Domestic Solid Fuel Burner Authorisation Manual (2011).

This manual is a reference for regional councils and unitary authorities that act as authorising agents. It is also intended to be a useful reference for manufacturers and retailers selling and installing solid fuel burners in New Zealand.

Burners may be authorised in accordance with the regulatory requirements of the NESAQ, and/or the relevant regional plan.

In practice, Environment Canterbury effectively operates as the national authorising agency for several categories of solid fuel burners including woodburners, pellet fires and domestic small scale boiler systems.

Environment Canterbury makes an assessment as to whether a burner meets the requirements of the NESAQ and publishes emissions and efficiency data on their website as well as providing this information to Ministry for the Environment for publishing on their website. Burners need to meet the requirements of the local area so, for instance, while the Ministry for the Environment website lists all burners with emissions less than 1.5 g/kg, a homeowner looking to install a burner into Rotorua would only be able to consider those that meet the local rules, i.e. 0.60 g/kg or less.

The process for authorisation of different categories of solid fuel burners is as follows:

Woodburners

Environment Canterbury requires testing to AS/NZS 4012 and AS/NZS 4013 for low emission burners, and to CM1 for ULEBs to be undertaken by an independent laboratory or practitioner accredited by an accreditation authority, such as International Accreditation NZ (IANZ).

There are two accredited test laboratories in NZ, namely Spectrum Laboratories in Auckland and Applied Research Services in Nelson. There are also test laboratories in Australia that are capable of testing solid fuel burners to the relevant standards but in practice woodburners sold in NZ are generally tested in NZ.

Once a burner has been tested, an application for authorisation is made to Environment Canterbury. Test reports and other relevant information supplied by the applicant are audited by an independent technical expert. A recommendation is then made as to whether the burner should be authorised and what, if any, changes to the burner, its labelling, consent conditions etc are required.

This independent audit is a crucial step in the authorisation process not only to check for errors and inconsistencies in the test report, but also to consider what issues, if any, have the ability to negatively impact on airshed management, meeting the NESAQ requirements or other relevant issues. This could include identifying any issues in relation to the tamperability of the burner, or considering whether any special requirements should be specified, such as in relation to air circulation fans. The independent audit will also include reviewing any functionally equivalent test reports from overseas and deciding whether they are acceptable, and making adjustments to the results as necessary, to make a fair comparison with the requirements of AS/NZS 4012 and AS/NZS 4013.

Once authorised, a resource consent is issued and the burner is added to public listings on Environment Canterbury and Ministry for the Environment websites showing details of the burner such as manufacturer, make, model, emissions and efficiency data and other relevant information such as whether it is a freestanding or insert model and whether it has a wetback.

Pellet fires

Most, if not all, currently authorised pellet fires are manufactured overseas and are typically tested to the European standard EN 14785. This test data is submitted as part of the authorisation process.

The authorisation process for a new pellet fire is similar to that for a woodburner, i.e. the test results are audited and any adjustments made to the results as necessary such as adjusting for differences in how quantities are defined between Europe and NZ, before Environment Canterbury's technical auditor makes a recommendation on their authorisation.

Domestic boiler systems

Domestic boiler systems are generally manufactured overseas. They are typically electronically controlled and designed for the specific purpose of heating hot water which can then be circulated throughout a home by way of a radiator system for home heating.

Boiler systems are excluded from testing to AS/NZS 4012 and AS/NZS 4013. Typically such systems will have been tested to a relevant international standard such as EN 303-5. This method is recognised as a functionally equivalent method, as referred to in the NESAQ.

When a boiler system is submitted for authorisation the test results are audited and any adjustments made to the results as necessary. In particular, EN 303-5 calculates emissions and efficiency on the basis of wet wood (which is different to AS/NZS 4012 and AS/NZS 4013 which uses a dry wood basis). Efficiency in Europe is based on energy in, not useful energy out as in NZ. This means that the emissions figures from EN testing will be lower, and efficiency figures will be higher in comparison with AS/NZS 4012 and AS/NZS 4013 and will need to be adjusted to consider the change of basis in order to provide an "apples with apples" comparison with test results from other burners.

EN303-5 also specifies hardwood as a test fuel compared with the softwood that is specified for testing in NZ. An analysis of the emissions from the hardwood burn cycles compared with softwood burn cycles from ULEBs tested between 2015 and 2017 showed that, on average, emissions from the hardwood cycle were 20% higher than for the softwood high burn cycle. The EN303-5 emissions data would therefore be a conservative assumption for NZ conditions and would overstate the likely emissions from using softwood.

3.4 Market trends in efficiency and emissions improvements, new technologies

Efficiency and Emissions Trends

There is a clear trend in reducing levels of emissions from woodburners over time. This has been driven by ongoing reductions in the allowable level of emissions at a national level (NESAQ) and in those set by various regional councils. The graph in Appendix 2 shows the emissions levels of currently authorised woodburners and the majority of emissions are under 1.0 g/kg.

As shown in Table 3, the allowable level of emissions at a national level has steadily reduced over time. This has encouraged manufacturers and suppliers to continue to design cleaner burners or to source them from overseas, particularly Europe.

Some regional councils e.g., Environment Canterbury, Otago Regional Council, Bay of Plenty Regional Council and Nelson City Council have set more stringent standards than those specified in the NESAQ as part of their strategies to meet their respective air quality goals. This has also spurred manufacturers and suppliers to supply burners to meet these tougher standards.

In particular, Environment Canterbury has played a market leading role with their development and implementation of the ULEB concept, which is discussed in detail in section 3.7.1.

Feedback from woodburner manufacturers at the time of Environment Canterbury proposing the ULEB concept around 2013 was that it would be "very difficult, if not impossible" to design a woodburner to meet this level of emission. However, Environment Canterbury has now authorised 35 ULEBs from 11 different suppliers. While ULEBs are designed to meet the specific emissions criterion set by Environment Canterbury based on real life emissions, these burners must also all be tested to AS/NZS 4012 and AS/NZS 4013 in order to verify that they meet the NESAQ requirement of 65% efficiency as measured by AS/NZS 4012. The average emissions results of all ULEBs is just 0.4g/kg, based on testing to AS/NZS 4013. This shows that the development of ULEBs primarily for the Canterbury market has played a leading role in reducing emissions in burners that are available nationwide.

There are no obvious trends with woodburner efficiency levels. The burner design process is effectively an optimisation to achieve the required standards of emissions and efficiency. As the allowable emissions level has been reduced over the years, there has been an ongoing trade-off between the two factors. More air improves combustion, reducing emissions but results in greater heat loss up the flue and therefore lower efficiency. Manufacturers design their burners to achieve the required level of emissions and may then find that they fall short on the efficiency criterion and need to make changes to recover some of the efficiency lost. This is discussed in more detail in section 3.5.

New Technologies

A new breed of woodburner appeared on the NZ market in early 2015 – the ULEB, which is designed to meet Environment Canterbury's ULEB emissions criteria.

The first ULEBs to be authorised were of a downdraught design effectively using two chambers for combustion. Initially these burners were sourced from Europe and then NZ manufacturers designed their own.

Wood is placed into the top chamber where it is partially burnt and gasified. When the fire has reached a sufficient operating temperature the operator pulls a handle (or this is done automatically in the case of the RAIS Bionic Fire) to divert the gases into the bottom chamber where they are burnt cleanly.

More recently, various NZ manufacturers have developed single chamber designs that, in some cases, are simply variations to an existing low emission burner design made in order to meet the ULEB criteria. This has generally involved modifications to the design to increase the primary and secondary air supply and improve the distribution within the combustion chamber so as to reduce the emissions from combustion. However, this has the effect of reducing efficiency. Design changes are required to mitigate this, such as increasing the heat transfer surface area or incorporating an air circulation fan into the design.

Another design concept that has appeared in NZ in the last two years is the catalytic combustor range which is a single chamber design with only primary air supply (no secondary air supply). This model achieves its low emissions by channelling the combustion gases through a catalytic combustor while in normal operating mode. This combusts unburnt components reducing emissions entering the flue. The catalytic combustor will not operate unless it is at an elevated temperature. AS/NZS 4012 and AS/NZS 4013 standards have provision for catalytic combustors.

Pellet Fire Solutions began importing the Blaze King range of burners of this design from North America in 2016 and there are now six variations of this range authorised as ULEBs. Since then, Glen Dimplex (Masport brand) has designed and manufactured a woodburner in NZ using the same concept, which was authorised by Environment Canterbury as a ULEB and LEB in 2019.

There are also two ranges of European sourced gasification boilers that have been authorised as ULEBs and LEBs. These are designed to heat hot water to be used in radiators for home heating. They are automatically controlled and designed to be a clean and efficient method of burning wood to provide hot water. They have been tested to EN 303-5 and test results have been audited, and adjusted as necessary to ensure a fair comparison with existing authorised burners, by Environment Canterbury's independent technical expert as part of the authorisation process.

Another type of technology recently authorised that is new to NZ is the Tonwerk T-SKY and T-ART models, sourced from Europe. These are single charge burners which are filled with firewood, ignited and then the door is shut. The appliances are fitted with a self-closing combustion chamber door that locks automatically. They contain steel plate structures clad with heat-resistant tiles for heat storage and slow release. No refuelling is required. This is incompatible with the processes defined in AS/NZS 4012 and AS/NZS 4013 which require refuelling at various times over the burn cycle.

Further details of the test methods and authorisation process used for the Tonwerk models are provided in section 3.8.

Illustrations of various burner types are provided in Appendix 3.

A summary of the burner types to be included in the amended NESAQ and relevant test methods efficiency and emissions is shown in the following table:

Table 5: Summary of Burner Test Methods and Results

Burner Type	Test Method	Typical emissions	Typical efficiency	Likely to meet amended NESAQ
Boiler system - pellet	EN 303-5	0.1 to 0.2 g/kg	80%	Yes
Boiler system - wood	EN 303-5	0.26 to 0.4 g/kg	83 to 85%	Yes
Cookers	EN 16510 Part 2-3	>1g/kg	<65%	No
Multi-fuel burner	AS/NZS 4012 and AS/NZS 4013	>1g/kg	>65%	No
Open fire	Not tested	>1g/kg	<65%	No
Pellet fire	AS/NZS 4886 and AS/NZS 5078; or EN 14785	0.1 to 0.8 g/kg	70 to 88%	Yes
Slow release burners	EN 15250	0.8 g/kg	77%	Yes
Woodburner	AS/NZS 4012 and AS/NZS 4013	0.2 to 1.5 g/kg	65 to 80%	Yes

3.5 Design "trade-offs" made by manufacturers between emissions and efficiency when designing new burners.

In any appliance, the most complete combustion and the lowest particulate emissions occur when a fuel load is burning with a plentiful combustion air supply. This is also the operating condition that results in the lowest thermal efficiency, as increased air supply rates also result in increased flue gas heat losses. In contrast, reducing the combustion air supply increases particulate emissions and thermal efficiency, due to reduced flue gas heat losses. Particulate emissions and thermal efficiency are therefore always being traded off against each other in burner design.

When attempting to design a ULEB, various manufacturers have reported being able to achieve ultra-low levels of particulate emissions (of the order of 0.1 to 0.3 g/kg), yet struggle to achieve the last few percentage points of thermal efficiency in order to meet the NESAQ criterion of 65%. As a result, the options available to the manufacturers include:

- Changing the burner design to achieve 65% efficiency while significantly increasing the level of particulate emissions.
- Using devices such as electric air circulation fans to improve heat transfer and boost the efficiency to the required 65%.
- Abandoning that design.

One manufacturer reported designing a burner producing emissions of 0.2 g/kg and 63% efficiency and then having to make changes to the design to achieve 65% efficiency that had the effect of doubling particulate emissions to 0.4 g/kg. Another manufacturer reported designing an ultra-clean burner, but the efficiency was 64.5% and was thus not NESAQ compliant. These are typical scenarios reported by burner designers and illustrate what seems to be a high price to pay in terms of emissions production in order to achieve the last few percentage points of efficiency.

These examples of emissions vs efficiency trade-offs have been verified by independent test laboratories.

A solution to this situation would be to allow some flexibility with the efficiency criterion for very low emission burners, and insert models in particular, as discussed in section 3.7.1.

3.6 Proposed amendments to the NESAQ and potential impact

There are two key proposed amendments to the NESAQ that will potentially impact on the solid fuel burner market:

- To reduce the maximum allowable level of emissions from new woodburners to 1.0 g/kg.
- To Include all types of new domestic solid-fuel burners under the existing woodburner regulations for emissions limits and thermal efficiency. This would include **all** types of domestic solid-fuel burners such as coal burners, multi-fuel burners, pellet fires, open fires, cookers, and water boilers.

The potential impacts of these amendments are discussed below:

3.6.1 Move to a national emissions standard of 1.0 g/kg as proposed in the NESAQ consultation document

There are various opinions within the industry as to whether this move is worthwhile or not. Some consider that this will unnecessarily restrict choice in areas where there is no air quality issue, while others see it as an ongoing progression towards cleaner burners.

The data shows that there is likely to be minimal impact on the woodburner market from a move to lower the maximum allowable emissions from 1.5g/kg to 1.0 g/kg.

There are currently 298 authorised woodburners (excluding wood fired boiler systems and those without test results) listed on the Ministry for the Environment website. Of these burners, 275 (92%) have emissions of no more than 1.0 g/kg. A move to a maximum allowable emissions level of 1.0 g/kg would therefore exclude only 8% of these currently listed burners. The impact will be less than that as in numerous locations such as Canterbury, Nelson and Rotorua local rules have already prohibited the installation of all these burners that would be excluded if the limit was reduced from 1.5 to 1.0 g/kg.

There have been 32 woodburners added to Ministry for the Environment's list of authorised burners in the last two years. Some of these burners have at least 2 variants, e.g. a log stacker base and a pedestal base, so they are counted as individual burners within this figure of 32, so the number of individual firebox designs will less than the 32 total. Of these burners, all but one have emissions under 1.0 g/kg. The range of emissions is from 0.2 g/kg to 1.1 g/kg with the average emissions from the 32 recent burners being 0.59 g/kg.

Nearly half of these new burners were designed to meet the requirements in Canterbury and have been authorised as ULEBs. The data shows that industry is unlikely to have any real problem in designing or sourcing burners with emissions of 1.0 g/kg or less.

Of the 48 insert model woodburners authorised under the NESAQ, the average emissions is 0.79 g/kg and the average efficiency is 67.2%. These figures are slightly dirtier and slightly less efficient when compared with the data for the 250 authorised freestanding woodburners of 0.73 g/kg and 68.8% efficiency respectively. Of the 48 insert models, 43 are sub 1.0 g/kg and would therefore comply with the proposed new NESAQ emissions limit.

There are specific challenges with insert models in meeting Environment Canterbury's ULEB criteria and the required 65% efficiency and these are discussed further in section 3.7.1.

3.6.2 Include a broader range of solid fuel burners under the NESAQ

Pellet burners

Pellet fires are designed to burn a standardised fuel, being a pellet made of compressed sawdust or wood waste, in a controlled combustion device. Pellet fires are manufactured overseas and generally tested to European standard EN 14785. Because of the standardised nature of the fuel and the controlled combustion occurring in a pellet fire, there is likely to be little difference between test results and real life operation of the burner and certainly much less than would be the case for a conventional woodburner.

Test results from the European standard have been considered as acceptable for the purposes of authorisation in NZ, after making any adjustments as necessary based on the test method used. This includes compensating for the European test data being supplied on the basis of net calorific value (NCV) of the fuel in order to make it consistent with the gross calorific value (GCV) of the fuel specified in AS/NZS 5078:2007.

All pellet fires currently listed on the Ministry for the Environment website meet a maximum allowable emissions level of 1.0 g/kg and would therefore not be impacted at all by a reduction in the maximum allowable emissions to 1.0 g/kg.

Testing of pellet fires should be allowed to be carried out to a recognised standard such as EN 14785 or the new EN 16150 standard when it becomes operative.

Water boilers

There are already several wood fired and pellet fuelled boiler systems authorised as low emission burners and most also qualify as ULEBs. These systems are generally imported and tend to be electronically controlled to efficiently burn wood or pellet fuel to create hot water to be used for home heating.

Recent examples authorised have been tested to the functionally equivalent EN 303-5 method.

Because of the automated control systems included in the design, and the use of standard fuel in the case of pellet fired boilers, water boilers tend to operate cleanly and efficiently. For example, the Froling and Spark ranges of boiler systems range from 0.26 to 0.4 g/kg emissions and 83 to 85 % efficiency for wood fuelled and from 0.1 to 0.2 g/kg emissions and around 80% efficiency for pellet fuelled models.

Such burners would not be impacted by a move to a 1.0 g/kg emissions limit.

Testing of boilers should be allowed to continue to be carried out to a recognised standard such as EN 303-5 or EN 16150 when it becomes operative.

Multi-fuel burners (MFBs)

There are a small number of MFBs burning wood and coal available in the NZ market from suppliers such as Yunca, Harris Home Fires and Jayline. As they are currently excluded from the NESAQ there is only limited emissions data available for these burners. Harris Home Fires offers the RMF multi-fuel fire which they describe as “the clean choice” on their website https://www.woodsman.co.nz/rmf and show an emissions level of 3.9 g/kg for this model. Glen Dimplex’s now obsolete Hestia and Kronos MFBs had emissions of 2.56 g/kg and 3.6 g/kg respectively. Environment Canterbury’s 2009 emissions inventory shows emissions rates for MFBs when burning wood are three times that of pure woodburners, and six times higher when burning coal.

MFBs are a compromise design and have to deal with the quite different combustion characteristics of wood and coal. Coal has a high level of fixed carbon and a low level of volatiles whereas wood is the opposite with low fixed carbon and high volatiles. This affects the requirements for primary and secondary combustion air and can result in poor emissions performance if wood and coal are burnt simultaneously or interchangeably in quick succession.

The fundamental difference between a MFB and a conventional woodburner is that a MFB incorporates a grate for fuel to burn on whereas a dedicated woodburner is designed for the fuel to burn on a bed of ash.

Many MFBs are operated using solely wood as a fuel and thus represent a less clean way of burning wood compared with a modern woodburner.

There doesn’t appear to be any issue with MFBs being able to achieve a 65% efficiency standard.

MFBs are a niche product with low sales volumes. As a result, there is little appetite for manufacturers to develop cleaner models. They don’t meet the current 1.5 g/kg standard but can be used now as they are not covered by the NESAQ, except in regions where prohibited by local planning rules. On the basis of the information available it appears unlikely that MFBs could achieve the proposed 1.0 g/kg overall emissions standard and would therefore be unable to be installed in NZ if included within the NESAQ.

Cookers

Solid fuel fired cookers are not currently included within the NESAQ, although the proposed amendments proposes including cookers. Cookers are restricted or banned in some areas of NZ by regional council planning laws.

AS/NZS 4012 and AS/NZS 4013 exclude cookers, so a functionally equivalent standard would have to be obtained or developed, or an existing standard such as AS/NZS 4012 and AS/NZS 4013 would need to be modified. The new European standard could be used: EN 16510-2-3 Residential solid fuel burning appliances - Part 2-3: Cookers.

Solid fuel cookers are designed to be well insulated and to keep heat inside the oven. They are not designed to heat a room and may struggle to meet 65% efficiency. They are generally designed as multi-fuel burners but in practice most are fuelled by wood.

Solid fuel cookers are a niche product and have been described by staff of Broady's, a retailer of solid fuel cookers, as "a declining market". While exact sales volumes are unknown, market feedback suggests that they would be of the order of no more than a few hundred per year. This volume, coupled with the fact that purchasers are often from rural areas would suggest that there is little reason to be concerned about the emissions from solid fuel cooking outside of areas of dense population.

Data from "Napier, Hastings and Havelock North Air Emission Inventory" shows that 1% of households in Napier, Havelock North and Hastings have solid fuel cookers. It is not clear from this report whether this includes rural areas around those locations, or urban areas.

As various regions have developed rules for solid fuel cookers, and others could do so if desired, there seems to be little to be gained by including them within the NESAQ. Such a move would require cookers to achieve a minimum 65% efficiency and a maximum emissions of 1.0 g/kg and would effectively remove them from the market nationally.

Coal burners and open fires

For domestic heating purposes, coal is generally burnt in either an open fire or in a multi-fuel burner (MFB) where either of these burner types are allowed within local Council planning rules.

While once a popular fuel, the use of coal for home heating in NZ has declined rapidly. As at the 2013 Census 61,000 homes, or about 4% of NZ homes, used coal for heating, down from 160,000 homes in 1996. Many of these homes are close to traditional sources of readily available coal. Also according to 2013 Census data, 912 homes in NZ use only coal as a form of heating with 73% of those homes in the West Coast of the South Island, Otago or Southland.

MFBs are unlikely to meet a 1.0 g/kg emissions limit and open fires will not meet either this emissions limit or the 65% efficiency threshold.

Bringing open fires and MFBs under the NESAQ will effectively prohibit the installation of either of these types of burner and the use of coal as a fuel in new burners.

This will have an impact on those parts of NZ where coal is still a preferred heating fuel.

Open fires designed for burning wood, such as the Jetmaster brand, would also be unable to be installed owing to their likely inability to meet the required emissions or efficiency standards under the NESAQ. It is worth noting that new installations of open fires are already prohibited indefinitely in polluted airsheds.

Including open fires within the NESAQ would impact on situations such as heritage homes with open fires which can currently be allowed by local plan rules.

3.7 Other options potentially to include in an amended NESAQ and the likely impact

3.7.1 Use of a combined emissions and efficiency measure (mg/MJ based)

Background
The current NESAQ specifies an emissions factor not exceeding 1.5g/kg of fuel burnt, based on testing to AS/NZS 4013 and an efficiency factor of not less than 65% expressed on the basis of usable heat energy output to energy input from testing to AS/NZS 4012. The proposed NESAQ amendments include reducing the emissions limit to 1.0 g/kg while retaining the current 65% efficiency threshold.

Any measure of emissions has its advantages and disadvantages. There is an argument by some that the current emissions standard based on g/kg favours larger capacity burners, although this opinion is not unanimous. With larger capacity burners there is greater air flow and a faster combustion rate which can result in lower emissions on a g/kg basis. This could mean that smaller burners are less likely to meet the standard. A homeowner with a larger burner may end up operating it on a low airflow setting with the resultant higher emissions, or if using it on higher output settings, needing to open a window or door to let surplus heat escape. This is more of a concern in areas where councils have implemented a lower emissions limit. For the rest of NZ there are still numerous smaller capacity burners available that meet 1.0 g/kg.

In the USA and UK, emissions are generally reported on a g/hr basis. This has the advantage of reporting emissions on a time basis so that total emissions are a result of the g/hr figure and the time the burner is operating. However, this unit would favour smaller burners which burn less wood and therefore produce less emissions per hour.

In Europe the most common measures of emissions are expressed in terms of mg/MJ of energy in the fuel, i.e. based on the calorific value of the fuel. For example, in Austria the maximum allowable emissions level was reduced to 35 mg/MJ in 2015.

The choice of the 65% minimum efficiency value is believed to have been adopted by the NESAQ from a rather arbitrary and unscientific decision made by Environment Canterbury for their first Canterbury Regional Air Plan and was simply selected as being towards the upper level of what woodburners were achieving at the time. Some burners were achieving an efficiency of around 70%, but the level was set below that to ensure that a range of burners was available for sale. The minimum efficiency level in Australia is 60%, having been recently increased from 55%.

Environment Canterbury's approach
Around 2002 Environment Canterbury began working with the concept of expressing emissions in terms of milligrams of particulates per megajoule (MJ) of useful heat produced, or mg/MJ. This takes into account the quantity of particulate emissions based on usable heat generated by a woodburner. It embodies the percentage efficiency and the particulate emissions in g/kg and incorporates a standard figure for the dry Gross Calorific Value (GCV) of the firewood which is taken to be 20.1 MJ/kg.

The calculation is as follows:

Emissions in mg/MJ = (1000 x Emissions in g/kg)/(% efficiency x 20.1 MJ/kg)

The current NESAQ performance standard of 1.5 g/kg and 65% minimum efficiency equates to an emissions limit of 115 mg/MJ of useful heat. The proposed standard of 1.0 g/kg and 65% minimum efficiency equates to 77 mg/MJ.

A similar calculation could be used for pellet fires. Wood pellet fuel has a virtually identical GCV to wood logs. For example, the test fuel used in testing the Ravelli Rosa R70 pellet fire was recorded as 20.05 MJ/kg.

Environment Canterbury has specified an allowable emissions level of 38 mg/MJ as a criterion for authorisation of ULEBs. This is equivalent to 0.5g/kg emissions and 65% efficiency.

It is important to note that this criterion is based on real life testing to their "Canterbury Method", which is theoretically much tougher than testing to AS/NZS 4012/4013 and, in particular, includes emissions from the relatively dirty start-up combustion phase.

Environment Canterbury's adoption of a ULEB threshold measured in mg of emissions per MJ of useful heat output effectively allows some trade-off between emissions and efficiency to achieve an overall ultra-low level of emissions. Environment Canterbury does not specify any separate maximum emissions level in g/kg or any minimum efficiency level based on testing to CM1 for authorisation as a ULEB. However, all new burners must also meet the current NESAQ requirement to achieve 65% efficiency as measured by AS/NZS 4012.

This 65% efficiency threshold is constraining the development of some ULEBs, or resulting in higher emissions than would be the case if the efficiency threshold was slightly lower.

Referring to the table in Appendix 1, it can be seen that a burner with emissions of 0.5 g/kg and with an efficiency of 65% would qualify as a ULEB and also be NESAQ compliant, yet a burner emitting 0.45 g/kg with an efficiency of 64% based on AS/NZS 4012 testing would qualify as a ULEB, but not be able to be authorised under the NESAQ.

Insert burners

There is a particular issue with insert burners as it is harder to achieve 65% efficiency because of the nature of their design. Insert models are designed to fit into a chimney cavity and have been used to replace open fires over many years. Insert models differ from freestanding woodburners in that they do not have exposed sides to allow heat to radiate into a room.

Many existing insert models in homes are old and relatively dirty. Councils in airshed towns and cities would like to see them replaced with ULEBs or LEBs.

It is likely that households with an existing insert burner will prefer to replace them with a new insert burner as they will fit into the existing cavity. Replacing an insert with a freestanding model will encroach into living room space.

The current efficiency requirement of 65% is believed to be having the effect of hindering the replacement of older, dirty insert burners with cleaner models, particularly where councils have more stringent emissions rules than defined in the NESAQ.

Manufacturers report being able to design an insert burner with very low emissions e.g. in the range of 0.3 to 0.5 g/kg and get efficiencies based on testing to AS/NZS 4012 close to 65%, but not quite achieving it, getting results in the 60 to 65% range. Such a burner is therefore not compliant with the NESAQ and therefore could not be offered for sale, despite being very clean and with no significant downside to householders because of a slightly sub-65% efficiency result.

There is currently only one insert model available that has been authorised as ULEB compliant, the Metro Ultra Insert from Pioneer Manufacturing Ltd. This model uses an electric air circulation fan to help achieve 65% efficiency.

In recognition of the problem facing insert burners being authorised as ULEBs and with only one ULEB insert model on the market, Environment Canterbury is allowing waivers of their burner replacement rule for insert burners until more models are available for sale.

mg/MJ as a solution
It would be useful if consideration could be given to the use of a standard that embodies emissions and efficiency in a single unit (mg/MJ) as Environment Canterbury does for ULEBs.

This would effectively allow manufacturers to optimise the performance of their burners so as to achieve a well-performing fire with an optimum balance of emissions and efficiency. As mentioned in section 3.5, this could potentially halve emissions from some burner designs at a cost of perhaps 2 percentage points of efficiency.

While Environment Canterbury currently bases a mg/MJ figure on CM1 test results, there is no reason why AS/NZS 4012 and AS/NZS 4013 test results could not be used to calculate a mg/MJ figure based on AS/NZS 4012 and AS/NZS 4013 results that could be included within proposed amendments to the NESAQ without needing to commit to a change in test method.

A burner producing 1.0 g/kg emissions and 65% efficiency equates to 77 mg/MJ, so this could be set as the NESAQ standard to be met. Having additional limits on emissions in g/kg and % efficiency would ensure that no particularly dirty or inefficient burners could be authorised.

Another potential option would be to allow a slightly lower thermal efficiency, provided that a tighter standard of emissions could be met. For example, if a burner could achieve emissions of less than, say, 0.5 g/kg, then the minimum efficiency standard could be reduced to 60%. If emissions were greater than 0.5, but less than 1.0 g/kg, then 65% efficiency would need to be met.

Consideration should be given to a new standard as follows:

- Maximum of 77 mg/MJ, and
- Maximum of 1.0 g/kg, and
- Minimum 60% thermal efficiency

All figures would be based on testing to AS/NZS 4012 and AS/NZS 4013.

This would provide manufacturers with some scope to design lower emission burners with minimal downside from a slightly lower efficiency standard.

Industry members spoken to in the course of this work and in prior discussions including laboratories, manufacturers and independent experts, generally consider that a householder would not notice a few percentage points difference in efficiency when operating their woodburner. As the efficiency level reduced, there is more likelihood that a householder would notice a difference, however this point would be under the proposed 60% level mentioned above.

Theoretically, from a financial perspective, if a householder used a typical amount of firewood, costing say $400 to $500 pa, then in a worst case scenario they would potentially use 1.08 (65/60) times that amount of firewood to produce the equivalent amount of heat from a 60% efficient burner compared with a 65% efficient burner. This would be equivalent to an extra $30 to $40 worth of firewood per annum. If the burner was 62.5% efficient, then this cost difference would theoretically be $15 to $20 pa. However, in practice it would likely be less than that as woodburners generally produce ample heat and a few percentage points difference in efficiency would result in little, if any, additional fuelling.

A manufacturer or supplier with a highly efficient burner could potentially use efficiency as a marketing tool to differentiate their product against any competitor's product that only just meets the standard.

Any move to allow a burner of less than 65% efficiency would require a change in the NESAQ to the new specified efficiency level as well as to clarify that the NESAQ overrules AS/NZS 4012. The reference to 65% efficiency in AS/NZS 4012 could potentially be removed at some future time when the standard is reviewed.

3.7.2 Regional Councils' ability to implement more stringent rules than the NESAQ

Under the proposed amendments to the NESAQ, individual councils may keep provisions that are more stringent than the NESAQ. Councils may also develop new plan provisions through standard processes that are more stringent than the NESAQ.

It is important for councils to retain the ability to set more stringent standards as each council has responsibility within their own airsheds to manage air quality and to develop strategies and initiatives that support this.

It would be useful however if there was more co-ordination between councils so to reduce the proliferation of different standards across different councils. This has an impact on burner manufacturers and suppliers where there are slightly different requirements in different regions, e.g. 0.60 g/kg for Rotorua and 0.7 g/kg in some Otago towns. There is unlikely to be much discernible difference in real life emissions between burners with these two limits.

One solution could be to have two levels of standards: one for polluted airsheds and another for all other areas. A specific set of criteria could be developed for the airshed areas. This could be based on specifying ULEBs for polluted airsheds. Another option would be to specify an emissions limit lower than the NESAQ, based on testing to AS/NZS 4012 and AS/NZS 4013, and make this consistent across all polluted areas.

This is a topic requiring further consideration and development.

3.8 Inclusion of all burner types and conflicts between the NESAQ and test methods/standards

The NESAQ states that discharge and efficiency of solid fuel burners covered by the NESAQ must be measured in accordance with the methods specified in AS/NZS 4013 and AS/NZS 4012 respectively.

AS/NZS 4012 and AS/NZS 4013 have a list of specific burner types that are excluded from these standards and can therefore be tested using a functionally equivalent method.

With new burner technology emerging, there is potential for burner designs to be caught in a conflict between the NESAQ and AS/NZS 4012 and AS/NZS 4013. Some burners may not be able to be physically tested to AS/NZS 4012/4013, yet are not specifically noted in the list of exclusions to testing to this method.

Where a woodburner is excluded from that method (refer to list of exclusions in section 3.2), another method may be used that is functionally equivalent. However, a burner not included in this list of exclusions is not able to be tested to a functionally equivalent method for the purposes of authorisation.

Recent examples of burners caught up in this apparent conflict are the Tonwerk T-Art and T-Sky wood storage heating stoves which have been submitted for authorisation by Envirosolve. Devices such as the Tonwerks were not contemplated in the NESAQ, the associated New Zealand Domestic Solid Fuel Burner Authorisation Manual or in Air Plans developed by various regional councils.

The Tonwerk can't be tested to AS/NZS 4012 and AS/NZS 4013 as the basis of its operation is to fill it once with firewood and not to refuel it. AS/NZS 4012 and AS/NZS 4013 specifies refuelling and at least three burn cycles.

As a result, the emissions based on testing to AS/NZS 4013 and the efficiency based on testing to AS/NZS 4012 cannot be determined. A functionally equivalent method is not able to be used as this can only be used for appliances specifically excluded from AS/NZS 4012 and AS/NZS 4013.

A laboratory opinion was provided stating that the Tonwerk burners cannot be tested to AS/NZS 4012 and AS/NZS 4013 due to the design and fuelling method required. The opinion letter states that the accredited test certificate for testing to the EN 15250:2007 (Slow heat release appliances fired by solid fuel – Requirements and test methods) standard provided by the applicant may be an applicable standard to use as a functional equivalent to allow for sale of the Tonwerks into the New Zealand market under the NESAQ regulations if they are able to meet the requirements. This was agreed to by Environment Canterbury's technical consultant who assessed the EN 15250:2007 standard against Environment Canterbury's Authorisation Procedure for Functionally Equivalent and was satisfied that the method used is suitable for consideration as a functionally equivalent method for AS/NZS 4012 and AS/NZS 4013.

The Tonwerks were also tested to CM1 by a NZ test laboratory. These test results were considered alongside European test results to EN 15250:2007 for the burner and supported by an opinion from the NZ test laboratory in order to authorise the burner as a NESAQ compliant burner and a ULEB.

There may also be instances of burners with small or unusual shaped fireboxes that either cannot accept the fuel loading regime specified in AS/NZS 4012 and AS/NZS 4013, or to do so would be to use the burner in a manner contradictory to that specified in the operating instructions and intended by the manufacturer.

For the purposes of the amended NESAQ, burners to be included within the NESAQ could be defined as "any domestic scale solid fuel burning device with the principal purpose of providing space heating for a home either directly, or via the heating of water for circulation, or a domestic scale solid fuel burning device for the purpose of cooking".

If cookers were to be excluded from the amended NESAQ then the definition could be altered to "any domestic scale solid fuel burning device with the principal purpose of providing space heating for a home either directly, or via the heating of water for circulation".

Consideration should be given in the proposed amendments to the NESAQ to refer to burner types in such a way that there is a testing process to follow for all current and potential burner types. Specifically, this should mention that if a burner can't be tested to AS/NZS 4012 and AS/NZS 4013 then a recognised, relevant test method can be substituted if agreed by the authorising agency and supported by advice from their independent technical advisors and/or a testing laboratory.

3.9 Potential options for test methods and standards

As mentioned in section 3.2, AS/NZS 4012 and AS/NZS 4013 are the standard test methods, or a functionally equivalent test method can be used where allowable. This section outlines potential changes that could be made to AS/NZS 4012 and AS/NZS 4013 as well as comments on other potential test methods.

3.9.1 Potential changes to AS/NZS 4012 and AS/NZS 4013

AS/NZS 4012 and AS/NZS 4013 were last updated in 2014. There are no fundamental concerns with the current versions of these standards and no immediate plans to review the standards. However, it could be useful at some point to address measurement uncertainty as a result of ever decreasing emissions levels and the resultant increase in percentage uncertainties in measurement. The emissions levels of the latest woodburners are of the order of $1/10^{th}$ that of emissions that were common when these standards were first developed.

If a decision is made to allow burners with efficiencies below 65% to be authorised, then an amendment should be made in section 9.1.2 of AS/NZS 4012 that references the minimum allowable efficiency specified in the NESAQ, or delete mention of the efficiency in the standard, as was the case in the earlier version on AS/NZS 4012.

3.9.2 The Canterbury Method (CM1)

Background

Around 10 years ago Environment Canterbury embarked on a project to measure the performance of solid fuel burners based on a test method designed to simulate real life operation of a burner. The objective was to have an emissions figure that would be a more reliable guide to emissions in actual life, compared with the idealised conditions of laboratory testing to AS/NZS 4012 and AS/NZS 4013. This information could then be used in airshed modelling as a more reliable guide to actual emissions from new burners.

A test method, known as the Canterbury Method (CM1) was developed that evolved from the real life emissions work done by Dr Angie Scott from Environment Canterbury. The method was based on the same test equipment and laboratory set-up as specified in AS/NZS 4012 and AS/NZS 4013 and with changes made to how the appliance is operated. This includes adding a ‘real life’ component, i.e. changing those specifications from the AS/NZS 4013 standard that relate more closely to how a typical householder might operate their fire in real life.

Professor John Todd from the University of Tasmania and a member of the standards committee for AS/NZS 4012 and AS/NZS 4013 (CS-062 Solid Fuel Burning Appliances) was also involved in the development of CM1.

The original draft of CM1 went through a peer review process before being adopted by Environment Canterbury. With the formation of the ULEB Industry Working Group (ULEB IWG) in 2014, the members of this group also reviewed the test method and recommended a number of changes to CM1, as follows:

- Fuel specification – being more specific about the description of firewood type and increasing the allowable size tolerances
- Loading – allowing laboratories to follow reasonable loading instructions prescribed in the relevant burner operating manual
- Sampling methods – allowing the use of in-stack measurement as well as the more common and originally specified dilution tunnel and calorimeter room methods, but only if the incumbent dilution tunnel and calorimeter room can’t be used for some physical reason.

The current version of the Canterbury Method is CM1.6.

CM1 inclusions

Key inclusions in CM1 that are excluded from AS/NZS 4012 and AS/NZS 4013 are:

- Measurement of emissions over the entire duration including the relatively high emissions period of start-up that is excluded from AS/NZS 4013.
- Testing based on real life firewood as might be obtained from a typical wood merchant and includes hardwood, softwood and partially seasoned burn cycles. This includes bark.
- Ember bed depth is greater than that required by AS/NZS 4012.
- Different fuel loads.

The two test laboratories carrying out testing to CM1 in NZ have both had their test processes audited by IANZ to verify that they are applying the processes specified in CM1 correctly.

Emissions and efficiency data from CM1 testing are averaged across the various test runs and used to calculate an emissions factor based on mg of particulate emissions per MJ of usable heat generated. This is then compared against Environment Canterbury's allowable limit of 38 mg/MJ in order to determine whether a burner will be authorised as a ULEB.

Recognition and value of CM1

One of the key useful aspects of CM1 is the expression of emissions in terms of mg/MJ (discussed further in section 3.7.1). This is simply a numerical calculation embodying both emissions and efficiency into a single measure that allows some degree of trade-off, within the constraints of the NESAQ.

Currently ULEBs, and the associated CM1 test method, are predominantly Canterbury concepts, although there is some recognition of ULEBs in other parts of NZ. For example, Nelson City Council requires a solid fuel burner to be authorised as a ULEB in order to be installed in Nelson. The only woodburners allowed in Bay of Plenty Regional Council's Rotorua Low Income Heating Grant programme and Otago Regional Council's Clean Heat Clean Air subsidy programme are ULEBs.

The development and adoption of the ULEB concept, based on testing to the simulated real life conditions specified in CM1 has been a valuable tool in encouraging the industry to design or source ever-cleaner woodburners.

The average emissions level based on testing to AS/NZS 4013 for the 35 ULEBs now authorised is 0.4g/kg. There are several NZ designed woodburners emitting only 0.2 g/kg and the cleanest of them all, the Tropicair Duo, produced test emissions of just 0.1 g/kg from testing to AS/NZS 4013.

Data from real life testing shows a positive correlation between real life emissions and laboratory test (AS/NZS 4013) emissions. So, the move towards designing cleaner burners to meet the ULEB criteria is leading to lower emissions from solid fuel burners in real life.

Issues to consider with CM1

The ULEB concept is playing a valuable role within Canterbury and for other regions that have recognised ULEBs. However, a move to recognise ULEBs, and the underlying CM1 test method, more broadly would require consideration of a number of issues including:

- While CM1 has undergone significant scrutiny as part of its development, this will not have been to the same degree of rigour involved in developing and refining an Australasian standard. It is worth noting, however, that there is some overlap between members of the Standards Committee for AS/NZS 4012 and AS/NZS 4013 and the development/review process for CM1.

- The replacement of AS/NZS 4012 and AS/NZS 4013 with CM1 in NZ would result in the Australasian standard only being used in Australia.
- The potentially lower level of reliable repeatability from testing to CM1 as it includes start up emissions and uses a fuel that can be variable in nature.
- ULEBs were conceived in Canterbury where there has been long-standing air quality issues. While there has been some recognition of the ULEB concept in other NZ airsheds, there will be less interest in CM1 from other non-airshed towns and cities.

While real life testing will provide a more accurate measure of particulates entering the air from solid fuel burners compared with testing to AS/NZS 4012 and AS/NZS 4013, there will always be variances between what is measured from testing and what occurs in real life, as can be seen in Table 6 and Table 7 in Section 3.10. Part of this will be due to the variation in the nature of firewood used. This will also result in differences between test laboratories as one will use a different source of wood to another, and firewood choice will also vary from householder to householder. This is inevitable and it would be contradictory to the intent of real life testing to specify a controlled source of firewood for real life testing.

There will also be differences in results arising from test laboratory staff being highly skilled operators of solid fuel burners compared with homeowners who will have varying levels of capability in operating a solid fuel burner.

However, the use of a test method based on simulated real life usage will provide data that is closer to what might be experienced in real life operation, compared with using AS/NZS 4012 and AS/NZS 4013.

Use of CM1 to grant LEB authorisation

Currently a manufacturer seeking authorisation of a burner as a ULEB needs to submit their burner for testing to two methods. Testing to CM1 is required for Environment Canterbury to consider ULEB authorisation. Testing to AS/NZS 4012 and AS/NZS 4013 is also required in order to verify that the burner meets the 65% NESAQ efficiency criterion and also to provide emissions and efficiency data for authorisation as a LEB for sales outside Canterbury and Nelson.

This effectively doubles the testing cost for manufacturers and there is an argument from some manufacturers that because CM1 is a theoretically tougher test, then authorisation as a ULEB should automatically grant LEB authorisation. There are a number of issues to address before this could be considered, including:

- There have been some inconsistencies with test results whereby AS/NZS 4013 emissions data are higher than that from CM1 testing. This is unexpected as CM1 testing includes the dirty start-up period.
- A decision would need to be made as to what efficiency and emissions figures would be reported for LEB authorisation. This could be the CM1 test data, or emissions could be adjusted to account for the extra emissions that could be expected from the CM1 test cycles.
- Whether there are any opportunities to “game” the CM1 test to gain a back-door authorisation as a LEB.

Future options

In order for CM1 to be used and recognised more broadly, there would need to be a new, higher, level of scrutiny applied to it.

As the names imply, AS/NZS 4012 and AS/NZS 4013 are trans-Tasman standards. There is currently only limited awareness in Australia of CM1. Woodburner standards throughout Australia have historically been less stringent than in NZ, with Australia having just tightened their national standard in September 2019 to a maximum emissions of 1.5 g/kg, down from 2.5 g/kg.

While it would be theoretically possible to develop a trans-Tasman standard based on real life testing either as a modification to AS/NZS 4012 and AS/NZS 4013 or as the development of a new standard, the process would be lengthy. CM1 has been a useful tool in Canterbury to lead the development of a new range of ULEBs. However, any national specification of ULEBs would rule out many good heating options for areas not needing such a strict emissions level.

Using regulations such as the NESAQ, and in conjunction with allowable stricter local air plan rules where relevant, standards based on results from testing to AS/NZS 4013 could be just as effective and less of a shift compared with moving nationally to a test method such as CM1.

Another option would be to specify an additional burn cycle to capture the start-up emissions during AS/NZS 4013 testing. This could be referred to in the proposed amendments to the NESAQ as using AS/NZS 4013 for emissions testing "with the following modifications".

3.9.3 International – Laboratory Test Methods

A new European set of standards (EN 16510-1 Residential solid fuel burning appliances - Part 1: General requirements and test methods) is being developed. This standard is structured to have a set of general requirements and test methods, supplemented by specific procedures for a variety of burner types. This recognises that some aspects of the standard should be common across all types, e.g. efficiency calculations, while other aspects are tailored to the particular requirements of a range of different heater types.

EN 16510 part 1 together with part 2 will supersede EN 13240 for roomheaters, EN 13229 for inset appliances, EN 12815 for cookers and EN 12809 for independent boilers. It is also intended that EN 16510 will replace EN 14785 for space heating appliances as well as EN 15250 for slow heat release appliances.

The structure of EN 16510, Residential solid fuel burning appliances, is as follows:

- Part 1: General requirements and test methods
- Part 2-1: Roomheaters
- Part 2-2: Inset appliances including open fires
- Part 2-3: Cookers
- Part 2-4: Independent boilers — Nominal heat output up to 50 kW
- Part 2-5: Slow heat release appliances
- Part 2-6: Appliances fired by wood pellets

The benefit of this approach is that standards are tailored to the requirements of particular burner types, within an overall common approach. This contrasts with the current Australian/NZ approach of having different standards for different burner types and, in some cases, trying to use a test method where it is not ideally suited to the burner being tested. However, the type of fuel and how it is burnt in the EN test will vary from NZ conditions.

3.9.4 International – Real Life Test Methods

Internationally there is also interest in a real life emissions testing regime with the development of the "BeReal" test programme in Europe. This is based on the need for refined testing procedures in order to differentiate between poor and excellent products based on operating conditions as they are found in real life installations.

The key objective of BeReal are:

- Development of advanced testing methods for room biomass heating appliances to better reflect real life operation
- Development of a centralised standard evaluation tool for quality assurance purposes
- Validation of methods at an early stage of development
- Proof of real life impact of advanced products by field test demonstration
- Proof of reliability and reproducibility of testing methods and evaluation tools through a Round Robin test
- Development and introduction of a quality label based on the novel testing methods

The September 2018 IEA report on the BeReal project concludes that an implementation of a real-life reflecting test protocol (e.g. BeReal) as a quality label or standard should be considered as an instrument to push technological development further towards optimised real-life operation. Additionally, this would also enable a better differentiation of good and poor products for the end customer regarding typical real-life use. The use of a real-life oriented test protocol for determination of emission factors seems possible, but needs further investigations.

3.10 Commentary on real life emissions from solid fuel burners vs their laboratory test results and trends over time

It has been known for some time that actual emissions from woodburners are several times higher than those determined through laboratory testing to AS/NZS 4013 and its predecessors.

As mentioned in section 3.2, laboratory results from testing to AS/NZS 4012 and AS/NZS 4013 are based on testing under ideal circumstances using kiln dried test firewood and excluding the relatively dirty period of start-up emissions. This discrepancy does not represent a failing of the test method, but rather recognises that the purpose of AS/NZS 4012 and AS/NZS 4013 is to provide a reliable and reproducible basis of comparison between different burners and for excluding certain burners that fail to meet a specified criterion for the purposes of authorisation. It is not intended to indicate what emissions may be under real life operating conditions.

There have been six studies carried out in NZ over the last 14 years to assess emission levels of woodburners in real life through the use of in-situ emissions measurement and then to compare these results against the relevant laboratory test results.

The first four studies were carried out on NESAQ compliant burners (emissions <=1.5g/kg), as follows:

Table 6: Real Life Emissions Trials of LEBs

Year of study	Location	Average real life emissions recorded (g/kg)
2005	Christchurch	15.5
2006	Tokoroa	4.6
2007	Nelson, Rotorua, Taumarunui	4.6
2009	Christchurch	9.1

As can be seen, the average real life emissions recorded range from 4.6g/kg to 15.5g/kg, or 3 to 10 times the prevailing NESAQ standard of 1.5g/kg.

Two studies of the real life emissions of ULEBs were carried out in 2017 and 2018 in Rotorua and Waimate. The results of these studies are shown in the following table.

Table 7: Real Life Emissions Trials of ULEBs

Year of study	Location	Average real life emissions recorded (g/kg)	AS/NZS 4013 test emissions (g/kg)	CM1 test emissions (g/kg)
2017	Rotorua	1.0	0.10	0.35
2018	Waimate	1.58	0.17	0.30

This table shows that the ratio of emissions from in-situ testing is approximately ten times the emissions results from laboratory testing to AS/NZS 4013, i.e. towards the top end of the range seen in the earlier LEB trials.

However, the emissions from these ULEBs in the recent studies are lower than the real life emissions from the earlier trials of NESAQ compliant burners by a factor of 3 to 15. Based on these studies, these results show that the development of the new category of ULEBs has led to a significant reduction in emissions from laboratory testing but also, and more importantly, in their emissions from actual usage in homes. This situation could be summarised as “cleaner in the laboratory, cleaner in the home”.

Both of the real life trials of ULEBs were based on twin chamber downdraught ULEB designs. Now that single chamber ULEBs are available and are likely to be the more popular ULEB choice, it may be useful to conduct a real life trial of one or more single chamber ULEBs to see how they perform in real life.

Looking at the AS/NZS 4013 emissions and CM1 emissions in Table 7 one possible conclusion is that reduced real life emissions could be achieved by adopting lower regulated emissions levels based on AS/NZS 4013 testing without the need to implement a simulated real life testing method.

3.11 The appropriateness and workability of allowing secondary emissions reduction devices through the NES.

Technological solutions are available to be attached to a solid fuel burner to trap particulate emissions and thus reduce the quantity of emissions going into the air. Such technologies are not currently referred to in the NESAQ.

Environment Canterbury has referred to such devices in their CARP and has defined them as a “secondary emission reduction device” (SERD) with the purpose of reducing the particulates from a small-scale heating appliance.

Environment Canterbury and West Coast Regional Council have both investigated a specific example of a SERD, the OekoTube device manufactured by OekoSolve in Switzerland. Environment Canterbury has arranged laboratory testing on an OekoTube fitted to three low emission burners and West Coast Regional Council has installed OekoTubes in two homes in Reefton, one being a multi-fuel burner, burning wood and coal, and the other burning only coal.

The OekoTube is an emissions control device that can be fitted to any small-scale solid fuel heating appliance to significantly reduce the particulate emissions. The OekoTube uses electrostatic precipitation similar to the technology used on a much larger scale in industrial electrostatic precipitators such as at Huntly Power Station.

The OekoTube is connected to a mains power supply. A transformer within the device converts this to a high voltage of the order of 15000 to 30000V. A 1.5m long electrode within the device causes particulates to become polarised and are then attracted to the wall of the tube and accumulate into coarser material. These accumulated particles either fall off when they reach a certain size or are removed with the periodic cleaning of the device. Power used by the device is small, with a maximum draw of 30 W.

The OekoTube does not remove condensable volatile organic compounds in the flue gases. These compounds will condense out to form particulates at lower (ambient) air temperature.

Environment Canterbury has recently authorised the use of the OekoTube on burners up to a rated emissions of 1.5 g/kg on the expectation that at least 2/3 of particulates will be removed, thus making the burner/OekoTube combination effectively a sub-0.5 g/kg burner. Conditions of this consent include hard wiring it into the home’s power supply, using the OekoTube at all times that the burner is in operation and having a cleaning and maintenance contract to ensure that the device continues to effectively remove particulate material.

There is an argument that the performance of such devices is independent of the burner that they are connected to, i.e. the burner is simply a source of emissions. The effectiveness of the OekoTube is reported to be based on the amount of time it takes for flue gases to pass through the device.

Two small scale trials have been carried out in NZ to attempt to see how they perform.

Environment Canterbury and EECA collaborated on a laboratory trial of an OekoTube at Spectrum Laboratories in 2015. The purpose of this study was to test the OekoTube on three different sub 1.5g/kg woodburners. Testing showed an average particulate removal of 72%. Laboratory staff commented that the OekoTube was visually very effective, noting reductions in smoke from the flue and the build-up of particulates on this inside of the device – see photos below:

Figure 1: Inside of OekoTube After Operation

West Coast Regional Council also arranged laboratory tests on an OekoTube in 2014 at Applied Research Services which showed 90-97% removal of PM_{10} on low burner start-up and around 58% overall. West Coast Regional Council concluded from their field trials that the devices “worked well” in real life.

Secondary emission reduction devices such as the OekoTube have the potential to significantly reduce emissions from existing solid fuel burners and thus contribute to an improvement in air quality. The data indicates a threefold reduction in particulates, so the installation of an OekoTube on burners of up to 3 g/kg would effectively make their emissions performance on a par with the proposed amended NESAQ compliant 1.0 g/kg burner, providing that the device was maintained in good condition and remained connected to a power supply.

The cost of an OekoTube is around $2800 plus installation. Bulk discount pricing may be available. The NZ agent for the OekoTube (Envirosolve) proposes a compulsory servicing programme to go with the device so as to maintain performance.

A device of this nature could be an effective option for use in heritage buildings with open fires, or in conjunction with a coal burner where there is a local desire to continue to burn coal.

3.12 The use of air circulation fans to lift efficiency to the NESAQ standard and issues associated with these fans.

Pioneer Manufacturing recently (October 2018) had their Metro Wee Rad Ultra freestanding burner authorised as a ULEB by Environment Canterbury.

As part of their consent decision, Environment Canterbury required a permanently hardwired fan to be included in their Metro Wee Rad Ultra model.

It is clear that without an operational fan, the Metro Wee Rad Ultra would not achieve 65% efficiency as the efficiency with the fan operating is only just compliant at 67%. There is a risk that if it was left to the homeowner to plug the fire into an electricity socket, then they may opt not to do this with the result that efficiency would drop below the 65% required by the NESAQ and thus not be compliant.

The impact of a fitted fan not working would be less clear if the efficiency was well above 65%. However, it could be argued that a manufacturer would be unlikely to go to the trouble, expense and complexity of fitting a fan if the fan wasn't required to achieve the minimum efficiency threshold.

Section 3.5 of Ministry for the Environment's NZ Domestic Solid Fuel Burner Authorisation Manual notes that "Authorising agents may list further special conditions, as necessary, for the satisfactory implementation of the authorisation". However, it is not clear whether such conditions relate solely to installation in the agency's territory, e.g. Canterbury, or whether it relates to all of NZ.

Air circulation fans wired into a home's power supply draw only a small amount of electricity, typically of the order of 30 to 60 W. Assuming a draw of 45 W, 5 hours operation per day and an electricity cost of 30c/kWh results in an inconsequential daily cost of 7 cents to run the fan.

In some cases a manufacturer may use a thermoelectric fan (which derives its energy from the heat of the fire), for example the Harris Ferva Saturn ULEB. Such models will not be affected by any requirement to have the fan connected to a mains power supply in order to achieve the required efficiency level.

Consideration should be given to specifying that any solid fuel burner with an externally powered electric air circulation fan that is submitted for authorisation be consented with the condition that the fan must be permanently wired into an electricity supply. This should be a national requirement as the fan will be required to meet the NESAQ efficiency requirements. However, if the minimum efficiency limit was lowered slightly then there could be less need for manufacturers to resort to devices such as air circulation fans in order to achieve the required efficiency standard.

3.13 Solid fuel burner sales and price trends

Sales Trends

There is no national collation of sales data on woodburners in NZ. Individual territorial authorities (TAs) around NZ are responsible for issuing consents for the installation of woodburners and hold data for their respective jurisdictions. However, there are 67 TAs in NZ and they each hold data in varying formats and to varying degrees of quality and availability. It would potentially be possible to compile data from each TA, but this would be a time-consuming process.

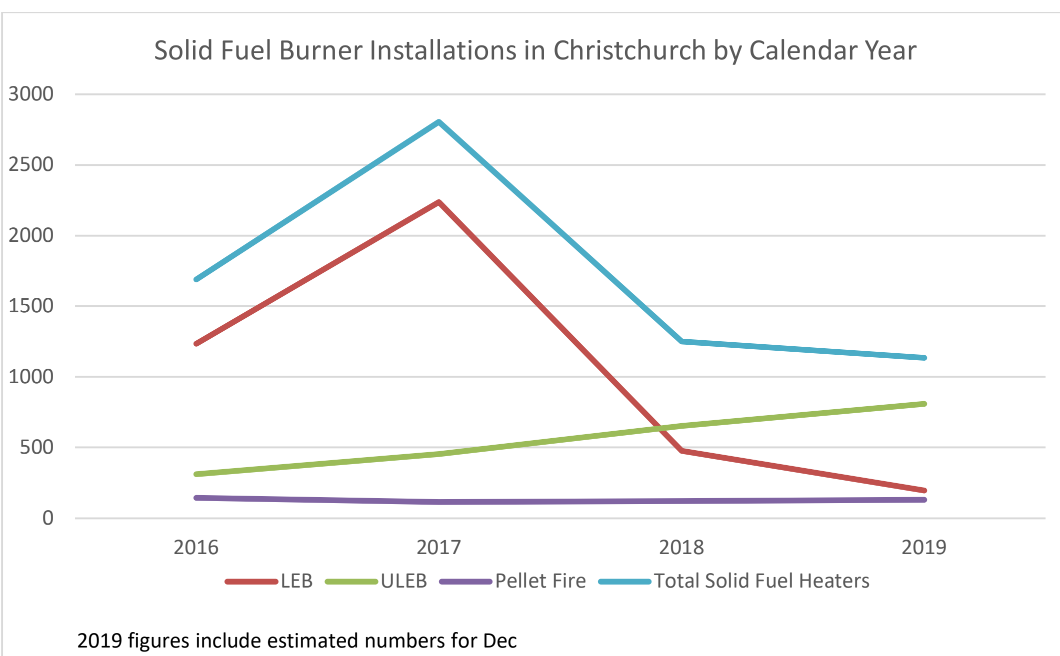
The NZ Home Heating Association (NZHHA) has provided an estimate of the current sales volume of woodburners in NZ of around 10,000pa. This is based on some industry members' own compilation of data.

The current trend is for a gradual reduction in sales volumes. Reasons for this include:

- An increasing desire for the simplicity of heat pumps
- Improving energy efficiency of new homes meaning that less heat is required, so smaller heaters such as heat pumps will meet the heating requirement.
- Confusion and lack of awareness as to what forms of heating are allowed in various regions. Regulations vary from region to region and also change from time to time within a region. For example, there is still a belief by some that solid fuel burners are not able to be installed in Christchurch, despite the law having changed to allow ULEBs in 2012 and the first ULEBs appearing on the market at the beginning of 2015.

Data has been obtained from Christchurch City Council on solid fuel burner installations in Christchurch over the last four years and this is shown in the graph below, segmented by pellet fires, LEBs and ULEBs.

Figure 2: Graph of Solid Fuel Burner Installations in Christchurch



Since 1 January 2019, only ULEBs can be installed in most airshed towns and cities of Canterbury. This has resulted in a major shift in sales from LEBs to ULEBs in Canterbury. The graph shows a 160% increase in the volume of ULEBs sold in Christchurch from 2016 to 2019.

It would be useful if information on solid fuel burner installations could be collated at a national level. This would involve setting up a process whereby TAs submit data on burner installations in an agreed format, capturing specific information, particularly the burner make, model, resource consent number and date of installation. This information would be useful for gaining an understanding of the nature of burner installations nationally, as well as regionally which would help with air quality management.

Price Trends

The early ULEB models submitted for authorisation were European models. The first ULEB was a Jayline Walltherm, which was authorised in December 2014, followed by models from two other European suppliers, being the RAIS Bionic Fire and the Xeoos Twinfire. When introduced, the Walltherm was priced at around $10,000 and the Bionic Fire and Twinfire around $8000.

On observing the authorisation of these overseas sourced ULEBs, New Zealand manufacturers became more confident in the ULEB opportunity and began to invest more time and money into research and the development of ULEB models. This led to ULEB models being designed and manufactured by New Zealand manufacturers including Tropicair, Glen Dimplex and Harris Home Fires. These were offered for sale at around $5500 to $6000. This had the effect of encouraging the suppliers of the early European ULEBs to reduce their prices in order to be competitive. The manufacture of the Jayline Walltherm was moved to China in order to help with reducing costs.

In NZ, the latest range of single chamber ULEBs has simplified manufacturing and led to further cost reductions. The latest single chamber ULEB from Harris Home Fires (Woodsman Serene) retails for $3400. This compares with similar specification LEBs in their ranges from $1650 to $2675. Pioneer Manufacturing (Metro Fires) offers a 15kW woodburner for $2675 in ULEB specification or $1749 in LEB specification, representing a price premium of $926 for the ULEB version.

All the above costs exclude installation and Council permits which would typically be of the order of $1000 and $400 respectively.

So, while ULEBs are still more expensive than LEBs, the price premium is declining.

The recommended retail price of LEBs has remained fairly stable over the last 5 years. For example, the Metro Wee Rad LEB retails for $1749 now compared with $1699 five years ago, despite being re-engineered to reduce emissions. While there have been cost pressures on labour and other manufacturing inputs, consumer price expectations are making it difficult for manufacturers to increase prices.

4. Other Issues Arising

During the course of this research a number of issues arose that are worthy of mention, including:

5 yearly re-authorisation of woodburners

A periodic re-authorisation of woodburners is required in order to help ensure that burners offered for sale are the same as that submitted for authorisation. Manufacturers are not able to make changes to their burner designs without seeking either re-authorisation, or an exemption from the re-authorisation process from the authorising agency. The 5 yearly re-authorisation process will identify any burners that have changed designs since their original authorisation.

Section 2.3 of the Ministry for the Environment's New Zealand Domestic Solid Fuel Burner Authorisation Manual requires the burner authorising agent (Environment Canterbury) to notify the authorisation holder in writing before the authorisation expiry date. Where feasible, a minimum of three months' notice is to be given.

An increasing number of solid fuel burners listed on the Environment Canterbury and Ministry for the Environment websites have expired consents.

An example picked at random is the XXXX[1]. Its consent expired in August 2017, yet it still appears on Environment Canterbury and Ministry for the Environment websites and is offered for sale by heating retailers.

All burners affected by this are LEBs and are therefore unable to be installed in many parts of Canterbury or Nelson. However, they are able to be installed in many other parts of the country.

A work programme is required in order to identify all affected burners and embark on a re-authorisation programme.

Potential for homeowners to purchase woodburners directly from international websites

With the ongoing rise in e-commerce it is possible that a homeowner could purchase a solid fuel burner directly from overseas that has not been authorised for use in NZ.

Caveat emptor would apply to such cases with the buyer being solely responsible for whether their purchase can be installed and taking the risk that they may have wasted their money.

However, there is a risk that such a burner might be installed or that the purchaser will be aggrieved at having wasted their money, so this prospect is something that could be considered in future planning.

There is also potentially a risk that a consumer could be sold a burner by a NZ based retailer that is not able to be installed in the home, however such an occurrence could be more easily dealt with than would be the case for purchasing online from an overseas based supplier.

[1] Make and model anonymised as potentially commercially sensitive.

5. References

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6. Glossary

CM1	Canterbury Method of testing
EECA	Energy Efficiency and Conservation Authority
GCV	Gross Calorific Value (of fuel)
IANZ	International Accreditation NZ
LEB	Low Emission Burner
MFB	Multi Fuel Burner
MJ	Megajoule
NCV	Net Calorific Value (of fuel)
NESAQ	National Environmental Standards for Air Quality
NZHHA	NZ Home Heating Association
SERD	Secondary Emission Reduction Device
TA	Territorial Authority
ULEB	Ultra-low Emission Burner

7. List of NZ and International Standards

- AS/NZS 4012: Domestic solid fuel burning appliances – method for determination of power output and efficiency.
- AS/NZS 4013: Domestic solid fuel burning appliances – method for determination of flue gas emission
- AS/NZS 4886:2007 Domestic solid fuel burning appliance - Pellet heaters - Determination of flue gas emission
- AS/NZS 5078:2007 Domestic solid fuel burning appliances - Pellet heaters - Method for determination of power output and efficiency
- EN 303-5:2012 "Heating boilers. Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW.
- EN 14785: 2006 Residential Space Heating Appliances Fired By Wood Pellets - Requirements And Test Methods
- EN 15250:2007 (Slow heat release appliances fired by solid fuel – Requirements and test methods)
- EN16510-1 Residential solid fuel burning appliances - Part 1: General requirements and test methods
- EN 16510-2-3 Residential solid fuel burning appliances - Part 2-3: Cookers

Appendix 1 – Relationship between emissions g/kg, emissions mg/MJ and efficiency

Emissions g/kg

	0.1	**0.15**	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**	**0.45**	**0.5**	**0.55**	**0.6**	**0.65**	**0.7**	**0.75**	**0.8**	**0.85**	**0.9**	**0.95**	**1**
Efficiency																			
50%	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
51%	10	15	20	24	29	34	39	44	49	54	59	63	68	73	78	83	88	93	98
52%	10	14	19	24	29	33	38	43	48	53	57	62	67	72	77	81	86	91	96
53%	9	14	19	23	28	33	38	42	47	52	56	61	66	70	75	80	84	89	94
54%	9	14	18	23	28	32	37	41	46	51	55	60	64	69	74	78	83	88	92
55%	9	14	18	23	27	32	36	41	45	50	54	59	63	68	72	77	81	86	90
56%	9	13	18	22	27	31	36	40	44	49	53	58	62	67	71	76	80	84	89
57%	9	13	17	22	26	31	35	39	44	48	52	57	61	65	70	74	79	83	87
58%	9	13	17	21	26	30	34	39	43	47	51	56	60	64	69	73	77	81	86
59%	8	13	17	21	25	30	34	38	42	46	51	55	59	63	67	72	76	80	84
60%	8	12	17	21	25	29	33	37	41	46	50	54	58	62	66	70	75	79	83
61%	8	12	16	20	24	29	33	37	41	45	49	53	57	61	65	69	73	77	82
62%	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
63%	8	12	16	20	24	28	32	36	39	43	47	51	55	59	63	67	71	75	79
64%	8	12	16	19	23	27	31	35	39	43	47	51	54	58	62	66	70	74	78
65%	8	11	15	19	23	27	31	34	38	42	46	50	54	57	61	65	69	73	77
66%	8	11	15	19	23	26	30	34	38	41	45	49	53	57	60	64	68	72	75
67%	7	11	15	19	22	26	30	33	37	41	45	48	52	56	59	63	67	71	74
68%	7	11	15	18	22	26	29	33	37	40	44	48	51	55	59	62	66	70	73
69%	7	11	14	18	22	25	29	32	36	40	43	47	50	54	58	61	65	68	72
70%	7	11	14	18	21	25	28	32	36	39	43	46	50	53	57	60	64	68	71
71%	7	11	14	18	21	25	28	32	35	39	42	46	49	53	56	60	63	67	70
72%	7	10	14	17	21	24	28	31	35	38	41	45	48	52	55	59	62	66	69
73%	7	10	14	17	20	24	27	31	34	37	41	44	48	51	55	58	61	65	68
74%	7	10	13	17	20	24	27	30	34	37	40	44	47	50	54	57	61	64	67
75%	7	10	13	17	20	23	27	30	33	36	40	43	46	50	53	56	60	63	66
76%	7	10	13	16	20	23	26	29	33	36	39	43	46	49	52	56	59	62	65
77%	6	10	13	16	19	23	26	29	32	36	39	42	45	48	52	55	58	61	65
78%	6	10	13	16	19	22	26	29	32	35	38	41	45	48	51	54	57	61	64
79%	6	9	13	16	19	22	25	28	31	35	38	41	44	47	50	54	57	60	63
80%	6	9	12	16	19	22	25	28	31	34	37	40	44	47	50	53	56	59	62
81%	6	9	12	15	18	21	25	28	31	34	37	40	43	46	49	52	55	58	61
82%	6	9	12	15	18	21	24	27	30	33	36	39	42	46	49	52	55	58	61
83%	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
84%	6	9	12	15	18	21	24	27	30	33	36	38	41	44	47	50	53	56	59
85%	6	9	12	15	18	20	23	26	29	32	35	38	41	44	47	50	53	56	59

Figures in body of table are mg/MJ

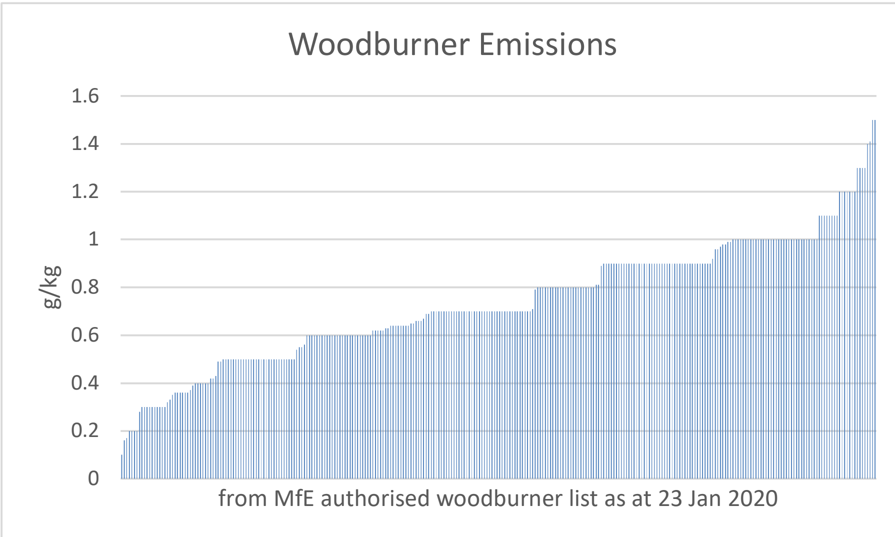
Green shaded: <77 mg/MJ heat output

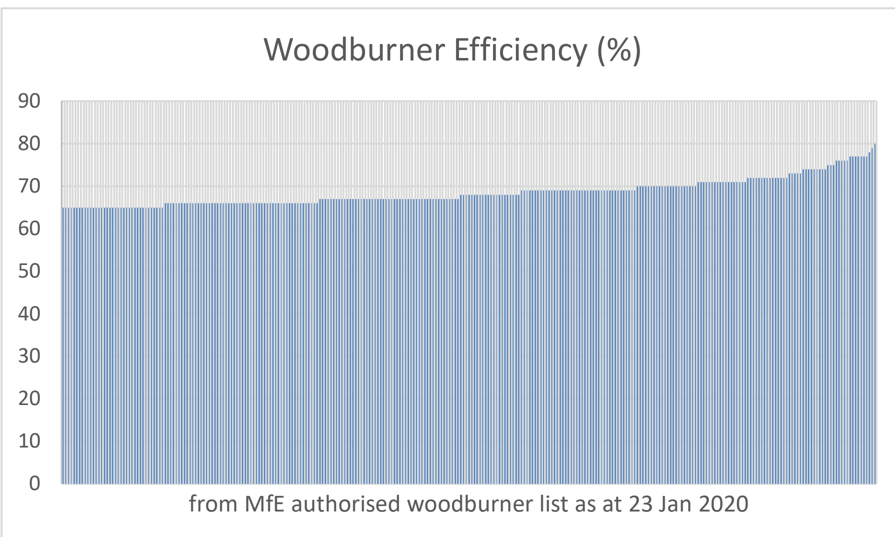
Red shaded: > 77 mg/MJ heat output

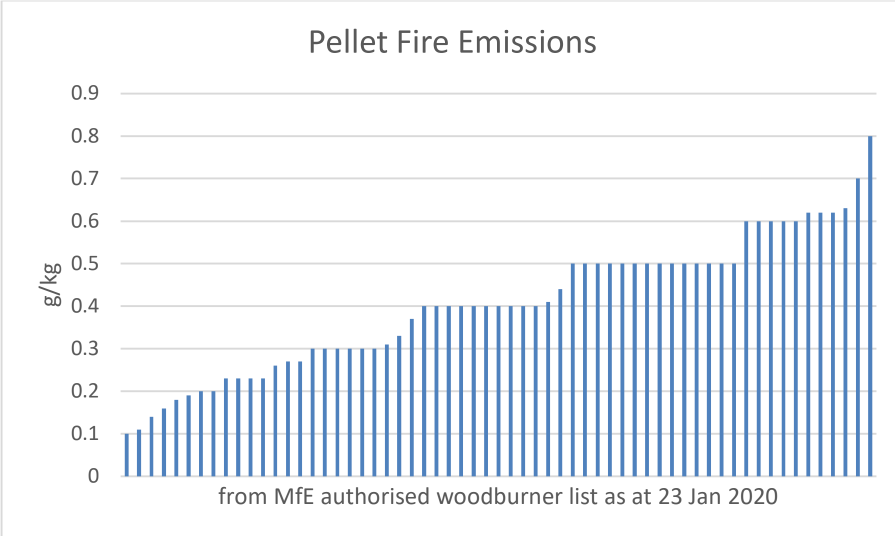
assume gross calorific value of firewood = 20.1 MJ/kg

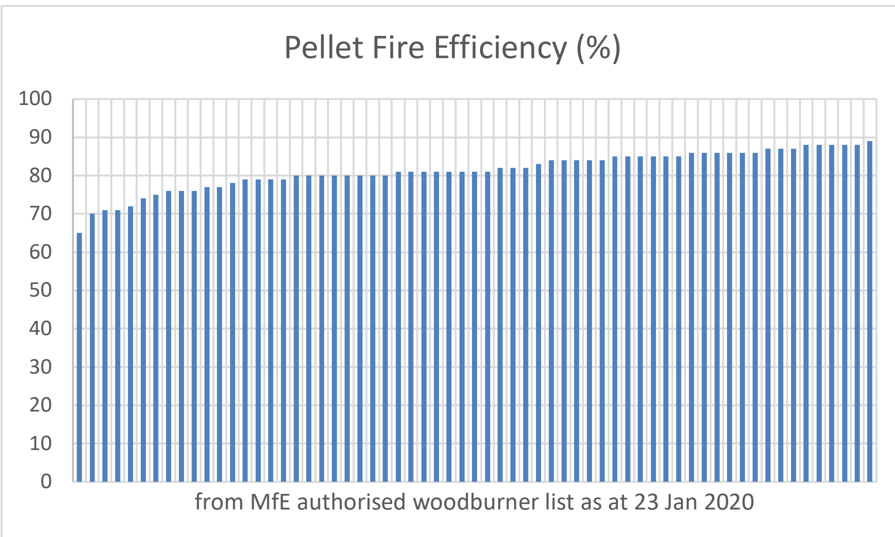
Appendix 2 – Emissions and Efficiency of Currently Authorised Woodburners and Pellet Fires

The following graphs show the distribution of emissions and efficiency for all currently authorised woodburners and pellet fires.






Pellet Fire Emissions
g/kg
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
from MfE authorised woodburner list as at 23 Jan 2020


Pellet Fire Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
from MfE authorised woodburner list as at 23 Jan 2020

Appendix 3 – Illustrations of Various Burner Types

 Conventional low emission burner showing air control lever at the top left and handle to open door for refuelling on right side.	 Twin chamber Ultra-low emission burner (ULEB)
 Single chamber catalytic combustor ULEB	 Multi-fuel burner
 Pellet fire	 Log fired boiler