Te Tūāpapa Kura Kāinga
Ministry of Housing and Urban Development

DOIA20/21030546

s 9(2)(a)

Dear s 9(2)

Thank you for your email of 20 February to the Ministry of Business, Innovation and Employment (MBIE) and forwarded to TeTūāpapa Kura Kāinga – Ministry of Housing and Urban Development (the Ministry) on 25 March requesting under the Official Information Act 1982 (the Act):

> *I am seeking information on https://www.legislation.govt.nz/regulation/public/2019/0088/latest/LMS160629.html#LMS160629 the formula in paragraph 2.*
>
> *Please provide all the correspondence including management directions, emails, memos, minutes, notes, ministerial briefing, cabinet papers around the selection and use of this formula.*
>
> *Additionally please provide any discussions you have had with industry or academia where you either sourced this formula or validated the use of this formula.*

You were advised on 27 April that, due to the large volume of emails held by the Ministry on this subject, your request would likely be refused under section 18(f) of the Act as it would require substantial collation or research to make the information available. You refined your request on 27 April to:

> *Can you please provide references to the source of this formula, and if the formula was developed by government can you please provide any independent review of the formula.*

As you will be aware, in December 2017 the Government passed the Healthy Homes Guarantee Act 2017, which amended the Residential Tenancies Act 1986 and enabled the development of standards to improve the quality of rental housing in New Zealand. On 1 July 2019, the Residential Tenancies (Healthy Homes Standards) Regulations 2019 (the standards) became law following feedback from public health experts and stakeholders, including landlords, tenants and building experts.

The heating formula in the standards was developed by MBIE officials (as part of the policy function that is now located at the Ministry) in consultation with the Energy Efficiency and Conservation Authority (EECA).

The Building Research Association of New Zealand (BRANZ) conducted a peer review of the heating formula developed by EECA for standalone dwellings, typically with small rooms. This peer review concluded that the heating formula is suitable for ensuring the majority of homes will be able to reach the target temperatures of the standards. The report prepared by BRANZ is attached. I have also attached an email exchange with BRANZ confirming their peer review of the heating formula. Mobile telephone numbers have been withheld from these emails under section 9(2)(a) of the Act to protect the privacy of natural persons.

NIWA reviewed the assumed external temperatures identified by EECA for the heating formula and their peer review report is attached.

In addition to these peer reviews, there was also a robust consultation process which sought feedback from other agencies, key stakeholders and technical experts in the industry, and the general public on several aspects of the standards, including the heating formula.

You have the right to seek an investigation and review of my response by the Ombudsman, in accordance with section 28(3) of the Act. The relevant details can be found on the Ombudsman's website www.ombudsman.parliament.nz.

As part of our ongoing commitment to openness and transparency, the Ministry proactively releases information and documents that may be of interest to the public. As such, this response, with your personal details removed, may be published on our website.

Yours sincerely

Claire Leadbetter
Manager
Tenures and Housing Quality

NIWA
Taihoro Nukurangi

07 March 2019

Mr Rod Harris
General Manager Housing Policy
Ministry of Housing and Urban Development
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Wellington 6140

Dear Rod

NIWA has carried out a peer review of the design minimum temperatures across New Zealand, as estimated by an analyst at the Energy Efficiency and Conservation Authority (EECA).

We have started by accepting the EECA methodology as a reasonable way of capturing typical external temperatures on the coldest day of the year. There are many ways that "cold nights" could be defined, and we accept that EECA have the expertise to assess such conditions as they may influence the heating requirements of rental homes.

To assess the robustness of the EECA result, NIWA has applied the same methodology as EECA, but to a different dataset – what we call the Virtual Climate Station Network (VCSN). In this case, we use the VCSN for daily minimum temperature, which has been produced by spatially interpolating observations at climate stations across New Zealand, and mapping the observations onto a grid at a resolution of about 5km.

In most cases, the minimum temperatures from NIWA's analysis are within one degree Celsius of those estimated by EECA, and the two sets of temperatures are highly correlated, leading to high confidence in the results of the EECA analysis. A high-resolution map is provided along with our appended report.

There is one issue that we would draw to your attention. The EECA analysis attempts to define a single design temperature for each local authority, when such areas are not in fact well-defined climate zones. Where temperatures are reasonably similar across a district, it should be possible to select a suitable external design temperature for the whole district. However, there are districts, especially in the South Island, where the minimum temperature drops rapidly as one moves inland from the coast. We would therefore recommend that you consider dividing such districts into two climate zones. Having regard to population centres, two districts stand out in this regard: the Buller district, distinguishing between Westport and Reefton; and the Hurunui district, distinguishing between Cheviot and Hanmer.

Sincerely,

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Enclosures: Appended Report, high-resolution map, gridded data for GIS analysis, excel spreadsheet

cc: Cade Bedford, Ministry of Housing and Urban Development
Christian Hoerning, Energy Efficiency & Conservation Authority

Peer Review of EECA Design Minimum Temperatures

The Energy Efficiency and Conservation Authority (EECA) has analysed minimum temperatures in local authority regions across New Zealand, in preparation for new regulations relating to the heating of rental homes. NIWA was contracted by the Ministry of Housing and Urban Development (HUD) to peer review this analysis. This short factual report assesses the robustness of the EECA analysis.

EECA provided NIWA a draft set of minimum temperatures for local authorities across New Zealand, along with a description of their methodology. During the period of the peer review, NIWA scientists met with technical representatives of HUD and EECA, to discuss preliminary results and resolve any discrepancies.

The EECA analysis used instantaneous hourly temperatures from climate stations archived in NIWA's National Climate Database, and extracted the lowest temperatures observed in each year 1998-2018. NIWA investigated the robustness of the EECA station-based approach by applying the same methodology to a different dataset of gridded daily minimum temperatures from NIWA's Virtual Climate Station Network (VCSN).

EECA's approach of dividing New Zealand into climate zones based on territorial authority regions seems a reasonable approach, which will cover much of the spatial variation in external design temperatures across the country. However, NIWA's analysis illustrates that large temperature differences can still occur within the same territorial authority region. Most of the spatial variation in temperature across New Zealand is due to changes in latitude, topographic elevation and distance from the coast (Norton 1985).

The estimates of external design temperatures from the EECA and NIWA analyses generally compare well to one another at the selected locations, leading to high confidence in the results of the EECA analysis. Prior to the NIWA analysis, EECA raised some queries about differing temperatures observed at climate stations in the same district or region; these queries are addressed individually in the Results section. In districts that contain sharp temperature gradients, some subjective decisions may need to be made about which design temperature is appropriate. NIWA considers that other agencies will be more qualified to make such decisions due to their experience in insulation and heating.

Where temperatures are reasonably similar across a district, it should be possible to select a suitable external design temperature for the whole district. However, some districts have sharp temperature gradients from the coastal regions, which tend to be more highly populated, to the more isolated inland regions, particularly in the South Island, e.g., Hurunui and Buller. Such districts could potentially be divided into two separate climate zones.

In 12 districts where EECA found no suitable climate station from which to determine an external design temperature, they have nominated a station from a nearby district to be used as a proxy. Due to the large number of districts, NIWA has not reviewed the choice of these proxy stations. However, NIWA's provision of a spatially complete map of design temperatures derived from the VCSN should now make it significantly easier for EECA to assess the appropriateness of candidate proxy stations from other districts.

NIWA has provided EECA with the results of their analysis in various file formats to accompany this report:

1. A high-resolution (600 dpi) map of external design temperatures across New Zealand, based on the VCSN, in PDF format. Figure 1 is a coarser PNG version of this map.
2. The gridded VCSN-derived data in a format suitable for analysis in a geographic information system (GIS), for example as ESRI ASCII grid text file.
3. Values of temperatures from the VCSN at locations of climate stations selected by EECA, as a Microsoft Excel spreadsheet file.

The next section describes the observational data and methodologies employed by NIWA and EECA to estimate external design temperatures. The results of the NIWA analysis and comparisons with EECA's analysis are then presented in the Results section.

Data and method

It is not feasible to determine an external design temperature for the exact location of every rental home in New Zealand. Instead, EECA proposed that New Zealand be divided into clearly defined climate zones and that each rental home is assigned the external design temperature of the representative climate zone in which it is located. EECA proposed using local authority area boundaries as climate zone boundaries and assigning a representative external design temperature to each local authority area. There are 67 territorial local authorities in New Zealand (including the Chatham Islands).

The method EECA used for selecting climate stations was to identify a station:

- within the relevant local authority area
- that has a minimum of 10 years of hourly temperature data within the period 1998 to 2018
- that has complete data records
- that is close to the most populated areas within the local authority area
- that is not too close to the sea, due to the moderating effect of the sea on air temperatures (except for areas where most of the population lives close to the sea)

EECA then defined the appropriate external design temperature based on climate data analysis:

- Design temperature to be the average of the annual lowest air temperatures over the period analysed, rounded to an integer number in degrees Celsius (no decimal points)

NIWA considers that this definition of design minimum temperature adequately captures the typical coldest night of the year. NIWA has done spot-checks of the hourly station temperature observations extracted by EECA from the National Climate Database (CliDB), but has not checked the arithmetic of the EECA analysis. Also, we note that local authority areas have been set up on the basis of catchments and other factors (e.g., political), and may not be homogeneous regions in terms of climate zones.

The NIWA analysis uses gridded temperatures from the VCSN to estimate design minimum temperatures across New Zealand. This provides an alternative (although not completely independent) observational dataset against which to validate the EECA analysis. The same metric was used by NIWA as employed by EECA – that is, calculate the average of the lowest minimum temperatures for each year 1998 to 2018 for every grid-point in the VCSN data set. The two approaches should be expected to provide generally similar results, and consistency between the two sets of results provides confidence in the EECA analysis.

The VCSN is a gridded data set of climate variables, which have been produced by spatially interpolating observations at climate stations across New Zealand. The VCSN provides full spatial coverage across the whole of mainland New Zealand at a resolution of 0.05° longitude and latitude, which is approximately 5 km. The VCSN data used in the present analysis were produced by interpolating station observations of temperature, assuming a spatially constant reduction in temperature with topographic height (i.e., lapse rate) derived by Norton (1985) (Tait and Macara 2014). VCSN temperatures may be less robust in remote regions with no nearby climate stations, and especially at higher topographic elevations due to uncertainty about alpine lapse rates (e.g., Jobst et al. 2017).

Daily minimum temperatures at all VCSN grid points were extracted from CliDB for the period from 1 January 1998 to 31 December 2018. The following two steps were then performed:

1. Find the minimum of the daily minimum temperatures in each year from 1998 to 2018, at all VCSN grid points. These values represent the lowest temperature recorded in each of these years.

2. Calculate the mean of the annual minimum temperatures across all years from 1998 to 2018, from the data produced in Step 1.

It should be noted that EECA derived estimates of external design temperatures from hourly instantaneous observations at climate stations. Within any 24-hour period, the actual minimum temperature is unlikely to fall exactly on the hour and may thus be below the minimum hourly instantaneous value. In contrast, the VCSN daily minima are derived from the actual minimum temperature observed in each 24-hour period from 9:00am to 9:00am. This could contribute to differences between the station-based and VCSN-based values, but this effect was found to be small.

Another source of difference is likely to be the spatial interpolation used to produce the VCSN temperatures. This means that, for example, multiple stations within any particular area may contribute to the value at the local VCSN grid point and those nearby. Also, the VCSN uses a thin plate smoothing spline to interpolate station observations, and this curve fitting allows for some deviation from station observations in order to produce a smooth, interpolated surface.

Results

Temperatures at individual stations, quoted within this report, are taken from the EECA analysis. T_s denotes the external design temperature derived by EECA, rounded to the nearest integer value in degrees Celsius; T_v denotes the external design temperature derived by NIWA from the VCSN, again rounded to the nearest integer value. In this report, "district" refers to the territorial area of a district council or city council.

The VCSN results are expected to be reasonable in locations with nearby climate stations, but should be treated with more caution in remote or alpine regions with no nearby climate stations. Temperature differences between coastal and inland locations are more pronounced in the South Island, where the topography rises more rapidly, leading to greater cooling. Annual and diurnal temperature variations also tend to increase with distance from the coast, leading to greater temperature extremes, and the effect of this continentality is also more evident in the South Island.

A map of external design temperatures across New Zealand derived from the VCSN (i.e., T_v) is shown in Figure 1. The locations of all climate stations nominated by EECA for each district are marked, as are the alternative climate stations identified by EECA, along with residential areas and boundaries of the territorial authorities. Also shown at each station location are T_s, and T_v from the nearest VCSN grid point. Figure 1 is rather small to see the finer details, but a high-resolution version has been provided as an attachment. Across all New Zealand grid-points, T_v ranges from -13 °C to +6 °C. Note that in Figure 1, temperatures at the low and high extremes are grouped together into two bins (-13 to 10 °C, and 3 to 6 °C), so as to preserve the map's colour contrast across the more highly populated regions of the country.

The EECA and NIWA temperatures at EECA's selected locations are directly compared to one another in Figure 1 and Figure 2. In Figure 1, each EECA location is followed (in brackets) by the EECA T_s and the NIWA T_v. Figure 2 is a scatter-plot comparing T_s and T_v at the locations at which EECA found a suitable climate station, excluding the Chatham Islands and the three alternative sites identified by EECA (Takaka, Reefton, and Hanmer Forest). Over these 54 locations, T_s ranges from -10 to +2 °C, while T_v ranges from -10 to +3 °C. Differences between T_s and T_v range from -2 to +2 °C. The mean difference ($\overline{T_s - T_v}$) is -0.06 °C, indicating very slightly lower temperatures in the NIWA analysis. This was expected, but the mean difference is trivially small. The mean absolute difference ($\overline{|T_s - T_v|}$) is 0.7 °C, which again indicates a relatively small average difference between the two estimates when rounded to whole degrees. (The attached Excel spreadsheet compares the differences before rounding the NIWA minimum temperatures).

The correlation between T_s and T_v is high ($r = 0.94$, $r^2 = 0.89$). Thus, the estimates of external design temperatures based on the station observations and the VCSN are fairly consistent with, and generally compare well to, one another.

The VCSN does not extend to the Chatham Islands, so the Chatham Islands have been excluded from the NIWA analysis. However, given the general consistency between the EECA and NIWA analyses, it seems likely that the EECA station-based estimate for the external design temperature will be reasonable in the Chathams.

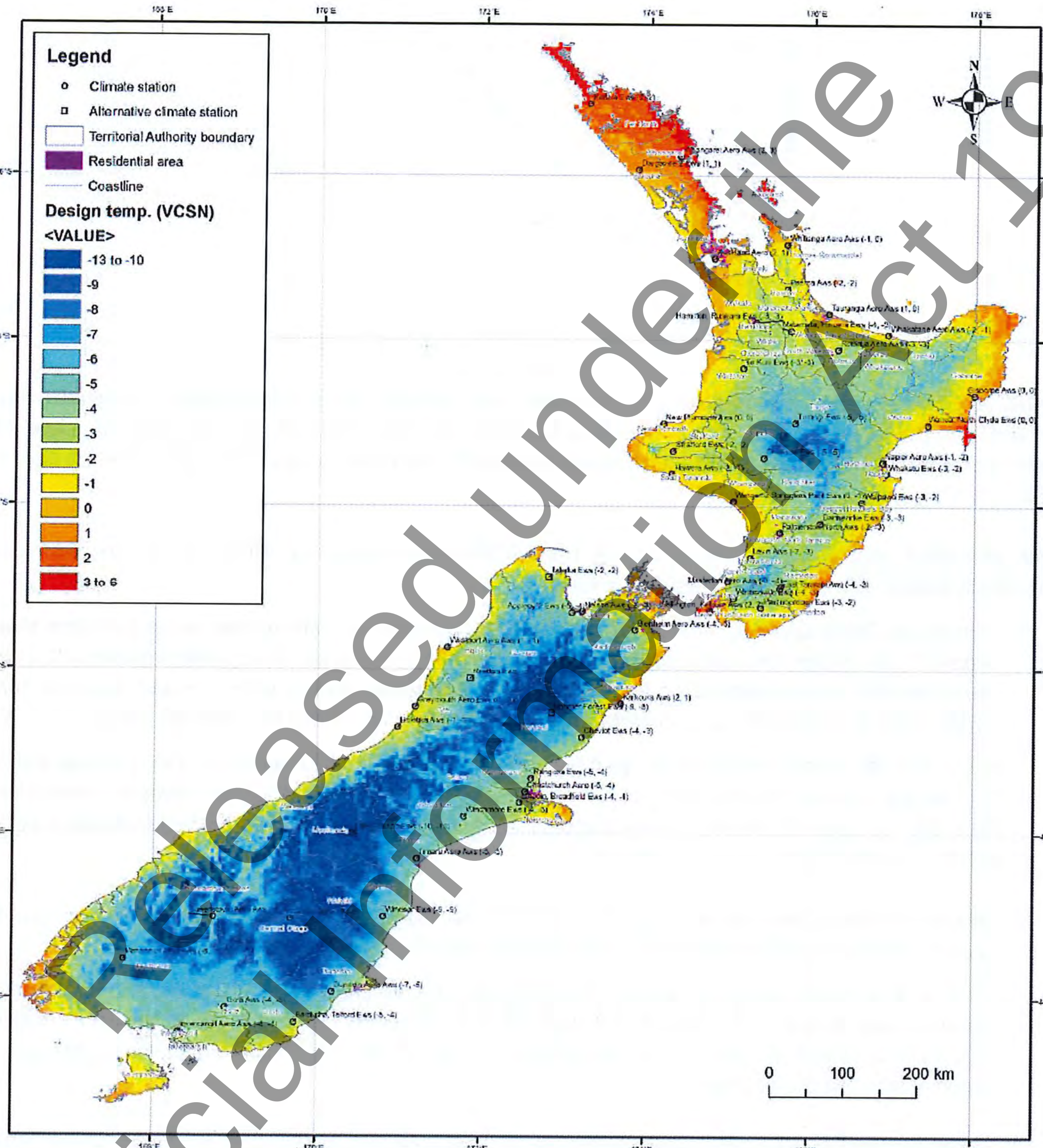

Figure 1: External design temperatures (coloured shading, °C) derived from the Virtual Climate Station Network (VCSN). Locations of climate stations are indicated by black circles; alternative climate stations are indicated by black squares. In brackets in the station labels are the station-based estimate of the external heating design temperature (T_s, °C), followed by the VCSN-derived estimate (T_v, °C). Also shown are territorial authority boundaries (sourced from Statistics New Zealand), residential areas (sourced from Topo50, Land Information New Zealand) and coastlines (sourced from CC-By Land Information New Zealand).

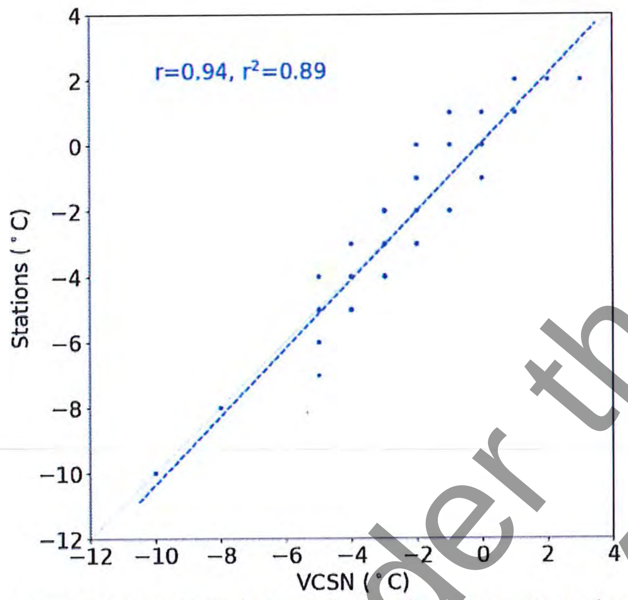

Figure 2: External design temperatures (°C) derived from climate station observations (T_s) versus those derived from the VCSN (T_v) (blue dots). The linear least-squares fit is indicated by the dashed blue line. The correlation coefficient (r) and coefficient of determination (r^2) are shown in the annotation. The 1:1 line is in grey.

EECA identified several issues where advice from NIWA was requested. These issues are addressed individually below, with the EECA comment in italics.

1. *Tauranga: The analysis of climate data for Tauranga suggests an external design temperature that is considerably higher than surrounding areas. In particular: Tauranga +1°C vs. Whakatane -2°C. Is this a reasonable representation of temperatures for the wider district or is this the result of some anomaly (e.g. particular micro-climate of climate station) that should this be moderated?*

   T_v is 0 °C in the area enclosing Tauranga city, and is -1 °C or 0 °C in the majority of the Tauranga district. T_v in coastal areas of the Whakatane district is around -2° C to -1° C, with lower temperatures inland. Thus, the Tauranga district does indeed appear to be a little warmer than both the Whakatane district and the Hauraki district to the northwest.

2. *Napier: Similarly, the analysis suggests a considerably higher design temperature for Napier than for nearby Hastings and Central Hawkes Bay districts. Should this be moderated?*

   T_s is -1 °C at Napier Aero Aws and -3 °C at Whakatu Ews, whereas T_v is -2 °C at the VCSN grid points nearest each station. A T_v value of -2 °C appears to be generally representative of the area enclosing both cities, as well as much of the coastal area of both districts, with some higher temperatures in coastal areas to the southeast.

3. *Tasman District: Whilst the Appleby climate station is closest to the most-populated areas of this district, it suggests an external design temperature of -5°C which appears low in comparison to Nelson and Takaka. Is this temperature representative for the wider district or should it be moderated?*

   T_s at the Appleby climate station is -5 °C. T_v is -4 °C at Appleby and at nearby coastal grid points to the northwest. At coastal grid points yet further to the northwest of the Tasman district, temperatures are a little higher, such as at Takaka where the T_v of -2 °C matches T_s at the local climate station. T_v at Appleby is indeed therefore somewhat lower than at Takaka and near the main residential areas of Nelson, where T_v is -3 °C to -2 °C. Inland parts of the Tasman district, away from the main residential areas, are considerably colder, falling to -10 °C or below.

4. *Hurunui: The Hanmer Forest climate station suggests considerably colder minimum temperatures than the Cheviot climate station. It is proposed that the Cheviot station is used to represent the district as it is more representative of the most-populated parts of the district. Does this seem reasonable? [Cheviot likely to be more representative for most of Hurunui population than Hanmer. Also, comparison to 3 years of Culverden data shows Culverden and Cheviot more similar, than Hanmer.]*

   In the Hurunui district, a strong temperature gradient runs from the southeast coastal region to the colder, more elevated inland region to the northwest. T_s is -4 °C at Cheviot, while T_v is -3 °C at Cheviot and Amberley and generally -3 to -4 °C near the coast. T_v is -6 °C or below throughout most of the inland Hurunui district, and -8 °C at Hanmer, where T_s is -9 °C at the local Hanmer Forest station. There are small pockets of other residential areas between the mountains and the Pacific coast, such as at Culverden where T_v is -6 °C. Given the 5 °C temperature difference between Hanmer and Cheviot, it may be necessary to use a lower external design temperature for Hanmer and other inland parts of the Hurunui district.

5. *Buller: There is a considerable difference between the coastal parts of the district (Westport, +1°C) and inland parts (Reefton, -5°C). It is proposed that a temperature somewhere between these two is chosen to represent the district, which would result in slightly oversized heaters in Westport and slightly undersized heaters in Reefton.*

   T_s is 1 °C at Westport Aero station, whereas T_v is -1 °C at the nearest VCSN grid point and generally around -3 to 0 °C near the coast of the Buller district. Approximately 50 km inland from the coast, T_s and T_v at Reefton are both -5 °C, with lower VCSN temperatures further inland. Possible approaches are to select an external design temperature somewhere between the T_v values at Westport and Reefton, or alternatively to subdivide the Buller district into two climate zones, coastal and inland, with a separate external design temperature for each zone.

References

Jobst, A.M., Kingston, D.G., Cullen, N.J., Sirguey, P. (2017) Combining thin-plate spline interpolation with a lapse rate model to produce daily air temperature estimates in a data-sparse alpine catchment. *International Journal of Climatology*, 37(1): 214-229.

Norton, D.A. (1985) A multivariate technique for estimating New Zealand temperature normals. *Weather and Climate*, 5(2): 64-74.

Tait, A., Macara, G. (2014) Evaluation of interpolated daily temperature data for high elevation areas in New Zealand. *Weather and Climate*, 34: 36-49.

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CONSULTING REPORT

MR12541 /1

COMPARISON OF THE TENANCY SERVICES HEATING ASSESSMENT TOOL TO LEGISLATION

CLIENT
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Report Issue Date: Draft for comment

Valid until: Click or tap to enter a date.

All tests and procedures reported herein, unless indicated, have been performed in accordance with BRANZ ISO9001:2015 Certification

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LIMITATION

TERMS AND CONDITIONS

This report is issued in accordance with the Terms and Conditions as detailed and agreed in the BRANZ Services Agreement for this work.

SIGNATORIES

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BRANZ

DOCUMENT REVISION STATUS

ISSUE NO.	DATE ISSUED	REVIEW DATE	DESCRIPTION
1	Draft for comment	Click or tap to enter a date.	Initial Issue

ISSUE NO.	DATE ISSUED	DESCRIPTION
1	Draft for comment	Initial Issue

1. EXEC SUMMARY

BRANZ has used five scenarios to test the Tenancy services online HHGA heat assessment tool. The results from the tool were compared to the results from manually implementing the formulae specified in the legislation.

Overall, the tool will produce acceptable result compared to legislation in the majority of cases, with the exceptions of the cases outlined below. A more thorough analysis could be undertaken if the source code to the calculator was made available.

The tool correctly calculates the heating requirements as compared to the legislation for plain rectangular geometry, however it can both under-estimate and over-estimate the heating requirement in more complex scenarios. There is also some inconsistency in the default R-values when the living space is not a simple rectangular box.

The tool slightly over-estimates the volume for skillion type roofs, and under-estimates this for more complex roof geometries. This leads to an overestimation of the air leakage losses in the skillion case, and an under estimation in the mixed ceiling cases.

A further check that could be incorporated into the tool would be to test whether the walls entered can enclose the floor area entered, this would minimize the chance of a wall being left out.

2. SCOPE

The tenancy services website contains a tool for assessing the amount of heating required in a rental property to be able to reach the desired indoor conditions in the HHGA. It translates the equation from the legislation so landlords can determine the required heating output by following a step by step process. The tool was launched on 1 July 2019 to align with the standards becoming law.

MBIE has gathered feedback on the tool since it launched and are now looking to better understand where the tool makes simplifications, and therefore may provide a slightly different output than the formula.

Some unusual results have also been noted, and BRANZ has sought to identify the nature of these in the course of this work.

This work tests five different scenarios across using the online tool accessible via the tenancy services website, and the formula as written in the legislation.

The five scenarios are:

1. Scenario 1: 1930's bungalow, with open plan lounge/dining/kitchen
2. Scenario 2: Loft style, converted warehouse apartment with mezzanine floor and irregular ceilings
3. Scenario 3: Small apartment, conventional layout in large apartment building
4. Scenario 4: 1990's semi-detached home with large living area including irregular ceilings and staircase
5. Scenario 5: 1950's brick former state house. Small living room.

Specific details of each scenario are included in the appendix. BRANZ created the content of scenarios 2,3 and 5, while MBIE created scenarios 1 and 4. As scenarios 1 and 4 were not created by BRANZ, the exact layout and geometry of the spaces were not known, and necessary assumptions were made during testing of the tool.

The remainder of the report outlines the findings.

3. RESULTS

Table 1 - Comparison of the online tool to manual calculation using the formula prescribed in legislation

	Heating requirements	
Scenario	Online tool result	Formula result
1	13kW	13.3kW
2	9.5kW	9.5kW
3	3.4kW	3.4kW
4	6.5kW	6.0kW
5	3.2kW	3.2kW

3.1 Discussion and observations:

Scenario 1:

The online tool estimates the heating requirement to be 13kW, 300W below the result based on the formula. This could be due to the calculation of the volume used in this scenario due to the mixed ceiling.

Rounding during the calculation could also be a contributory factor. At this point further investigation would be required to understand the origin of the differences between the calculator and the formula.

Scenario 2:

The online tool and the formula agree in the end result in calculating the heating requirements. We did notice however, that the highest wall in scenario 2 was used to calculate the ventilation volume, which overestimates the heating requirements by about 100W. This is likely due to the tool having to make assumptions ie using the height of the tallest wall rather than the average wall.

The effect of this has likely been nullified by rounding and other assumptions in the tool, which leads to the agreement in the final result.

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Scenario 3:

The online tool and the formula agree in their calculation of the heating requirements.

Scenario 3 is small apartment with 2 external walls (breezeway on entry side). It has a similar layout to scenario 2 (surrounded by similar apartments), however has no mezzanine. The living area has large sliding doors and a standard door for entrance.

Since the geometry is very simple it avoids any assumptions about the volumes and areas.

Scenario 4:

The online tool estimates the heating requirement to be 6.5kW, 500W above the result based on the formula. This could be due to the assumptions made in the calculation of the volume used in this scenario, as it has a mixed ceiling. There are also likely assumptions regarding which floor areas are shared space between the two zones.

Scenario 5:

The online tool and the formula agree in their calculation of the heating requirements.

Scenario five is a former state house, with a 4m by 5m living room on the corner of the dwelling. It has windows on 2 external walls, a flat ceiling with some insulation in the ceiling. The external walls are uninsulated and so is the floor.

Since the geometry is very simple it avoids any complicated assumptions about the volumes and areas.

3.2 Sensitivity analysis and extreme inputs:

The formula underpinning the tool is linear, so any change creates a linear change in the heating requirements. The implementation of the tool also appears to be fully linear in its response to a variety of inputs. Hence no special sensitivity to any particular variable is to be expected.

While there is filtering of values during the input stages of the tool, the limits placed on the inputs are much greater than what practical constructions are built like. An example of this is the ability to specify internal walls with an R value of 10. This is extremely unlikely to be seen in practice as it corresponds to a >300mm thick wall if insulated with fiberglass batts. It would be prudent to set a variety of limits in the tool. These could be based on the construction element being entered at the time, so that the limits corresponded to the practical limits of typical construction detailing.

4. GENERAL COMMENTS:

There doesn't appear to be a correction for volume in the air leakage calcs when there are mixed ceilings input. This could be difficult to implements given the assumptions that need to be made about geometry. From some testing it looks like the same stud height is assumed and this is ignored.

There is some inconsistency with respect to default R-values. In scenario 4 there is a mix of internal and external floor the tool suggests in the mixed case an external R value of 0.9 but for the non-mixed external floor an R-value of 1.3. In the mixed ceiling case in scenario 4, the R value of the ceiling defaults to 1.9 when none is selected. The behavior in case 1, under the same input conditions (but being only 1 level) defaults to an R value of 0.35. See screenshots in the appendix.

The tool also does not evaluate whether the wall lengths input are actually able to correspond to the floor area given. A simple sanity check that minimizes the chance of a wall being missed (or a typo) would be to ensure that the total wall length adds to be >= to the perimeter of a square enclosing the floor area that has been entered.

5. APPENDIX: TEST CASES

Scenario 1:

Scenario one is a 30's bungalow with open plan lounge/dining/kitchen. It has a mixed ceiling (some flat and some sloped) which is partially insulated and has a skylight .

Table 2 - Scenario 1 inputs

Section	Question	Data
1	Home built	1977 or earlier
	Region	Wellington
	Council	Hutt City Council
2	Floor area	78.55m^2
	Staircase	No
3	**Wall 1**	Internal
	Length	8.21m
	Height	2.7m
	Insulation	No change
	Wall 2	External
	Length	5m
	Height	2.7m
	Insulation	No change
	Window 1 length	2.9m
	Window 1 height	1.4m
	Glazing	single
	Wall 3	External

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	Length	13.21
	Height	2.7
	Insulation	No change
	Window 1 length	1.7m
	Window 1 height	1.4m
	Glazing	Single
	Window 2 length	1.1m
	Window 2 height	1.3m
	Glazing	Single
	Wall 4	External
	Length	7.5m
	Height	2.7m
	Insulation	No change
	Window 1 length	1.5m
	Window 1 height	1.1m
	Glazing	Single
	Door 1 glass length	1.2m
	Door 1 glass height	1.7m
	Glazing	Single
	Wall 5	Internal
	Length	5m
	Height	2.7m
	Insulation	No change
	Wall 6	Internal

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	Length	2.5m
	Height	2.7m
	Insulation	No change
4	Floor space	External
	Insulation	All
	R-value	1.5
5	Ceiling shape	Mix
	% flat ceiling	52%
	Ceiling space	External
	Insulation	Some
	Percentage	52%
	R-value	3.3
	Skylight	1
	Skylight length	1m
	Skylight width	0.5m
	Glazing	Single

Scenario 2:

Converted loft apartment, with mezzanine. Stairs to mezzanine internal to space, 1 open area assumed. It is also assumed that the unit is the top floor and surrounded by similar units (ie, 1 external wall with large windows)

Table 3 - Scenario 2 inputs

Section	Question	Data
1	Home built	1990
	Region	Wellington
	Council	Wellington City Council
2	Floor area	60
staircase to mezzanine	Staircase	No
	Level 1 floor area	25
3	**Wall 1**	External
	Length	7.5m
	Height	4.5m
	Insulation	Default
	Window 1 length	2.8m
	Window 1 height	2.5m
	Glazing	Single
	Window 2 length	2.8m
	Window 2 height	2.5m
	Glazing	Single
	Wall 2	Internal
	Length	8
	Height	4.75

	Insulation	Default
	Wall 3	Internal
	Length	7.5m
	Height	5.0m
	Insulation	Default
	Wall 4	Internal
	Length	8
	Height	4.75m
	Insulation	Default
4	Floor space	Internal
	R-value	Default
5	Ceiling shape	Flat
	% flat ceiling	100%
	Ceiling space	External
	Insulation	All
	R-value	Default

Scenario 3:

Scenario 3 is small apartment with 2 external walls (breezeway on entry side). It has a similar layout to scenario 2 (surrounded by similar apartments), however has no mezzanine. The living area has large sliding doors and a standard door for entrance.

The living/kitchen spans the full width of apartment, and the apartment is on the top floor.

Table 4 - Scenario 3 inputs

Section	Question	Data
1	Home built	2010
	Region	Wellington
	Council	Wellington City Council
2	Floor area	25.2
	Staircase	No
3	**Wall 1**	External
	Length	3.6m
	Height	2.4m
	Insulation	Default
	Window 1 length	3.4
	Window 1 height	2.2m
	Glazing	Double
	Wall 2	External
	Length	3.6m
	Height	2.4m
	Insulation	Default
	Door with no glas	

	Wall 3	Internal
	Length	7
	Height	2.4m
	Insulation	Default
	Wall 4	Internal
	Length	7
	Height	2.4m
	Insulation	Default
4	Floor space	Internal
	R-value	Default
5	Ceiling shape	Flat
	Ceiling space	External
	Insulation	Yes
	R-value	Default

Scenario 4:

Scenario four is a 1990 semi-detached house. It has a large living area with irregular ceilings (a mixture of flat and sloped) and two skylights. It also has a staircase to a landing on the next level.

Table 5 - Scenario 4 inputs

Section	Question	Data
1	Home built	1990
	Region	Wellington
	Council	Wellington City Council
2	Floor area	37.5m^2
Open staircase to downstairs area	Staircase	Yes
	Level 1 floor area	7.5m^2
3	**Wall 1**	External (garage on other side)
	Length	7.5m
	Height	2.4m
	Insulation	Default
	Wall 2	External
	Length	5.2m
	Height	3.4m (highest point)
	Insulation	Default
	Window 1 length	0.6m
	Window 1 height	1.6m
	Glazing	Single

	Wall 3	External
	Length	5.9m
	Height	3.4m (highest point)
	Insulation	Default
	Window 1 length	0.6m
	Window 1 height	1.6m
	Glazing	Single
	Wall 4	External
	Length	5.16
	Height	3.4m (highest point)
	Insulation	Default
Kitchen window	Window 1 length	1.35m
	Window 1 height	1m
	Glazing	Single
Balcony door	Door 1 glass length	1.36m
	Door 1 glass height	2.12m
	Glazing	Single
4	Floor space	Internal
	R-value	Default
5	Ceiling shape	Mix
	% flat ceiling	40%
	Ceiling space	External
	Insulation	None
	R-value	Default

	Skylight 1	
	Skylight length	1.2m
	Skylight width	1m
	Glazing	Single
	Skylight 2	
	Skylight length	0.8m
	Skylight width	1m
	Glazing	Single
Level 1 wall details	**Wall 1**	Internal
	Length	5m
	Height	2.4m
	Wall 2	Internal
	Length	1.5m
	Height	2.4m
	Wall 3	Internal
	Length	5m
	Height	2.4m
Level 1 floor details	Floor space	External
	Insulation	None
	R-value	Default
Level 1 ceiling details	Ceiling shape	Flat
	Type of space	Internal

Scenario 5:
Scenario five is a former state house, with a 4m by 5m living room on the corner of the dwelling. It has windows on 2 external walls, a flat ceiling with some insulation in the ceiling. The external walls are uninsulated and so is the floor.

Table 6 - Scenario 5 inputs

Section	Question	Data
1	Home built	1950s
	Region	Wellington
	Council	Wellington City Council
2	Floor area	19.5
	Staircase	No
3	**Wall 1**	External
	Length	3.6m
	Height	2.4m
	Insulation	Default
	Window 1 length	1.4
	Window 1 height	1.2m
	Glazing	Single
	Wall 2	External
	Length	5.4m
	Height	2.4m
	Insulation	Default
	Window 1 length	1.8m
	Window 1 height	1.2m
	Glazing	Single

	Wall 3	Internal
	Length	5.4
	Height	2.4m
	Insulation	Default
	Wall 4	Internal
	Length	3.6
	Height	2.4m
	Insulation	Default
4	Floor space	External
	R-value	Default
	Insulation	None
5	Ceiling shape	Flat
	Ceiling space	External
	Insulation	Yes
	R-value	Default

Out of Scope

From: Mark Jones <Mark.Jones@branz.co.nz>
Sent: Tuesday, 19 March 2019 2:45 pm
To: Cade Bedford <Cade.Bedford@hud.govt.nz>
Subject: RE: Following up on heating formula peer review

Hi Cade

I have managed to catch up with both Steve and Manfred and we are happy for you to say that we have peer reviewed the formula. They confirmed that the main concerns were around the transitions and recommended the sensitivity analysis on the data that the website returns, as you note. Other comments made are provided below:

- *Conductive heat losses: To outside – solid standard summation of conductive losses, good to see construction R values, and not just product R values.*
- *Heat loss to internal rooms: Good to see an attempt made to capture this, while the temperature of other internal rooms can vary, the assumption that unheated rooms sit at the midpoint temperature between the heated room and outdoors is a reasonable one to make. One could spend some time refining this, however given the complexity in the real world the difference in outcome would be minimal.*
- *Ventilation heat loss: The decision to assume 1 air change/hour of ventilation heat loss, while on the conservative side will not unduly penalise buildings on the margins of requiring a heat pump (vs resistive heater) as it will still be a minor part of the total. This also lines up with the BPI.*
- *Heating up power: Good to see the heating up power to account for the energy cost to bring the structure inside the thermal envelope up to temperature, as it is something that can easily be missed. The rationale behind the choice of the specific heating up power is solid. This coefficient depends on a number of factors like how long heating has been off for and the amount of thermal mass, and a pragmatic choice that reflects a majority of the buildings concerned has been made.*
- *In general: The proposed formula for calculating the heating load required is a good, well-reasoned piece of work, that aims to ensure the majority of homes will be able to reach the targeted temperatures without supplementary heating. Only in a very small minority of cases will it possibly lead to a heat pump being specified where resistive heating is sufficient or the converse, where an undersized heater cold be fitted. Making sure there is good guidance on the website on how to calculate the areas etc is also an important part of the success of the tool.*

Hope this helps
Kind Regards
Mark

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From: Cade Bedford <Cade.Bedford@hud.govt.nz>
Sent: Thursday, 14 March 2019 11:11 AM
To: Mark Jones <Mark.Jones@branz.co.nz>
Cc: Christian Hoerning <Christian.Hoerning@eeca.govt.nz>
Subject: Following up on heating formula peer review

Hi Mark

We are getting closer to finalising the regulation drafting for the healthy homes heating standard. I just wanted to follow up on the meeting Christian attended at BRANZ to peer review the healthy homes heating formula.

Thanks again for giving your afternoon to provide feedback on the formula. Having you and your colleagues review the formula helps us ensure the formula is robust and evidenced based.

My take away from the meeting was that doing some further sensitivity testing would be valuable but BRANZ did not recommend any changes to the formula.

Is this a correct summary of the peer review meeting? If we were questioned on the forumula's robustness would you be comfortable with us advising the Minister that the formula was peer reviewed by BRANZ and that you consider the formula appropriate for determining heating requirements for residential living rooms?

Kind regards,

Cade Bedford

Policy Advisor, Tenancy & Rental Housing Quality
Ministry of Housing and Urban Development

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