The required heating capacity of qualifying heaters in the main living room: A review of the methodology

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tailrisk economics

te maha hoki o nga pihikete

Tailrisk Economics

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Introduction

Nearly three years ago, our assessment[1] of the proposed "healthy homes" regulations questioned many of the arguments for insulation, heating, ventilation, moisture egress and draft stopping.

This paper focuses on the heating standard and reviews the methodology used to set a standard for the heating capacity of qualifying heaters in the main living room.

Landlords must provide one or more fixed heaters that can directly heat the main living room of rented properties. The heater(s) must be acceptable types, and must meet the minimum heating capacity required for the main living room. This capacity is determined by a formula set out in sub-part 2 of the Residential Tenancies (Healthy Homes Standards) Regulations 2019[2] . The formula calculates the kilowatts needed to reach a living room temperature of 18C given inputs on the heat retention properties of the room and an assumed minimum external temperature, which varies by location. The formula provides the basis for the online heating capacity calculator on the Tenancy Services website.[3]

In our view there are serious deficiencies in the formula and the supporting analysis. An inappropriate measure of external temperatures has been used. Heaters are expected to have the capacity to reached an 18 °C target assuming the temperature is at the lowest temperature that can be expected to be recorded during the year, which is generally at around six o'clock in the morning when there is an extreme frost. The minimum temperatures experienced during the day and night when the

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1 The proposed Healthy Homes Regulations: An assessment. December 2018, http://www.tailrisk.co.nz/documentlist

2 Residential Tenancies (Healthy Homes Standards) Regulations 2019. https://www.legislation.govt.nz/regulation/public/2019/0088/latest/whole.html

3 Heating Assessment Tool, Tenancy Services. https://www.tenancy.govt.nz/heating-tool/?gclid=CjwKCAjwmK6IBhBqEiwAocMc8oFVSbJt029CnHMWdJfHQ8LpIqRlEbyVJLDjgVTbEjJf6HGTYn0rhxoCNrAQAvD_BwE

living room is actually can be expected to be higher than the Ministry of Business Innovation and Employment's measure of the minimum in most locations. Their approach generates some perverse outcomes. The minimum temperature for Kapiti is 5^{o} C lower than in nearby Wellington. Wellington, along with Kaitaia, is rated as the warmest locality in the country.

Critically, the heating capacity formula appears to have been deliberately fabricated, to increase the requirement by inserting a 'floor space' measure, which has nothing to do with heating capacity needs, into the formula. This has the effect of pushing capacity requirements about 30 percent above standard industry capacity assessments. As a consequence, heat pumps will be required in some small living rooms where they are not economic or technically efficient, and many existing heat pumps, installed on professional advice, will be deemed to be no longer adequate.

We discussed the 'floor space' requirement in the calculation with a Tenancy Services policy analyst. He was unable to offer an explanation for the requirement, though he admitted that it did not appear to make sense.

The logic behind the heater capacity standard

The heating capacity standard is based on the proposition that heaters should be capable of heating the living room to 18 degrees Celsius in all circumstances. Accordingly, the capacity requirement is calibrated to the minimum expected external temperature. If the minimum external temperature is minus four degrees (for example in Christchurch) then the heater must be capable of increasing the internal temperature by 22 degrees. If it is two degrees (for example in Wellington) then the required increase is 16 degrees. A heater in a living room in Christchurch is required to have 22/16 =1.375 times the capacity of a heater of a comparable house in Wellington.

The basis for the 18-degree target

The rationale for the 18-degree target is a 2018 recommendation from the World Health Organisation[4]

> *Indoor housing temperatures should be high enough to protect residents from the harmful health effects of cold. For countries with temperate or colder climates, 18 °C*

[4] WHO HOUSING AND HEALTH GUIDELINES 2018

has been proposed as a safe and well-balanced indoor temperature to protect the health,

In its reviews of indoor heating in the 1980s, the WHO did not make general recommendation on indoor temperature levels, because there was insufficient evidence to base a recommendation on. Evidence on the issue was thin. One of the only directly relevant papers suggested that inside temperatures would have to get down to six degrees before healthy people would be affected. The WHO had noted, however, that the ill and the elderly could benefit from indoor temperatures above 17 degrees.

In the 2018 review, however, the WHO claimed that since their earlier reviews there was 'emerging evidence' that that cold indoor temperatures could have negative health effects. They reviewed the later literature but the evidence for an 18-degree cut-off was still thin to non-existent. However, they seemed to be determined to make some kind of recommendation and came up with the following play on words. They recommended:

Indoor housing temperatures should be high enough to protect residents from the harmful health effects of cold. For countries with temperate or colder climates, 18°C has been proposed as a safe and well-balanced indoor temperature to protect the health of general populations during cold seasons

The categorical cut-off point at 18 °C was based on the conclusions of a previous WHO working group on indoor environment finding that:

there is no demonstrable risk to human health of healthy sedentary people living in air temperature of between 18 and 24 °C".

The fact that there is no be any risk at 18 degrees is not, of course, evidence that there is a risk at 17 degrees or some lower temperature.

Because the weight that has been put on an inside temperature target of 18 degrees that must be reached at all times for health reasons, we have reviewed the evidence base the WHO used to support their recommendation, particularly focussing on how it might relate to living room temperatures. The WHO assessment reads as follows:

***Respiratory morbidity and mortality**.*
Of the four studies identified in the systematic review, three found that colder indoor temperatures increased respiratory morbidity.

1. *One cross-sectional study in adults with COPD (chronic obstructive pulmonary disease) found better health status with more hours of indoor temperature at and above 21°C. A close-response trend was observed or number of days with bedroom*

temperatures of 18 °C and above for at least nine hours. The greatest effects were observed in adults who smoked compared with non-smokers.

The study covered elderly, sick adults, not adults in general. Temperature had no impact on non-smokers[5], despite the inference in the WHO summary that there might be. The subjects were monitored for just one week. As the study just related to bedroom temperatures it is not necessarily relevant to a consideration of the impact of living room temperatures.

2. *Similarly, modelling based on the results of a randomized trial involving children with asthma found that every 1 °C increase in room temperature below the threshold of 9 °C, was associated with a small but significant increase in lung function. Bedroom exposure was shown to have stronger association with asthmatic children's lung function than living room exposure.*

As this study[6] considered just very low (below nine degrees) bedroom temperatures it was not relevant to a consideration of an 18 degree benchmark for living rooms. The actual impact on lung function was very small.

3. In addition, one cohort study, including adults with COPD, from China reported reduced respiratory problems with an indoor. temperature at 18.2 °C regardless of whether indoor humidity was low, moderate or high

This was a study[7] of 82 COPD patients. The full article was not freely available so we were unable to review the detail. The abstract just stated that the temperature should be kept at least on average at 18.2 degrees. This suggests that at times the temperature could be below that level, as long as the average was maintained

In contrast, a case-control study in children with and without upper respiratory tract infections showed no consistent associations with indoor temperature

This was an apparently robust United Kingdom study of 10,000 children which should be the preferred evidence on children and indoor temperatures.

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[5] Osman LM, Ayres JG, Garden C, Reglitz K, Lyon J, Douglas JG. Home warmth and health status of COPD patients. European Journal of Public Health. 2008;18(4):399−405.

[6] Pierse N, Arnold R, Keall M, Howden-Chapman P, Crane J, Cunningham M, et al. Modelling the effects of low indoor temperatures on the lung function of children with asthma. Journal of Epidemiology & Community Health. 2013;67(11):918−25.

[7] Mu Z, Chen P-L, Geng F-H, Ren L, Gu W-C, Ma J-Y, et al. Synergistic effects of temperature and humidity on the symptoms of COPD patients. Int J Biometeorol2017 Nov;61(11):1919-1925.
…

On this evidence, the WHO concluded:

> *The certainty of the evidence that warming a cold house (perhaps to a minimum indoor temperature of 18°C) would reduce the risk of respiratory mortality and morbidity was assessed as moderate.*

There was actually no evidence for the general population that warming houses to 18 degrees, as opposed to a lower number such as 16 or 17 degrees, would have any health impact. The best evidence on children was that there was no effect.

Cardiovascular morbidity and mortality:

> *Of the six included studies that assessed the association between indoor temperature and blood pressure, all showed that lower temperatures were associated with higher blood pressure, including two randomized trials in Japan that found higher blood pressure in people living in colder homes*

The first paper[8] compared the blood pressure of those sleeping in temperatures of 24.2°C and those at 13.9°C. It has no immediate bearing on whether 18 degrees was a cut-off for blood pressure impacts. While higher temperatures might lower blood pressure a little there is no evidence that this has health implications.

The second paper[9] found that when elderly people were instructed to turn-up their home heating in winter they generally did so, at least in the short run, leading to a decrease in blood pressure.

> *A cohort study in Japan of adults over 60 years of age found that decreases of 1°C in indoor temperatures were significantly associated with increased blood pressure levels at different times of the day, even after controlling for potential confounders.*

The association was with bed temperature. It is not clear whether temperature differences were due to differences in heating or the effectiveness of the bedclothes. It is also not clear whether the blood pressure differences were medically, rather than just statistically, significant.

> *Two cohort studies from Scotland found people in housing heated to less than 18 °C had a greater risk of high blood pressure). This risk increased if temperatures were below 16 °C (OR 4.92) (223)*

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8 Saeki K, Obayashi K, Iwamoto J, Tanaka Y, Tanaka N, Takata S, et al. Influence of room heating on ambulatory blood pressure in winter: a randomised controlled study. Journal of Epidemiology

9 Saeki K, Obayashi K, Kurumatani N. Short-term effects of instruction in home heating on indoor temperature and blood pressure in elderly people: a randomized controlled trial. Journal of Hypertension. 2015;33(11):2338–43.

The first study[10] assumed what was to be proven by splitting the data into above and below 18-degree cohorts, without an examination of the data to see whether at 18 degrees there was a natural break in the temperature/biomarker relationship. As a consequence, it compared cohorts with an average temperature that were about five degrees different. It is possible that the poorer performance for the sub-18-degree group could have been driven by results for much lower temperatures than 18 degrees.

The full text of the second paper was not publicly available.

> *Similarly, a cohort study[11] in the United Kingdom found a decrease in systolic and diastolic blood pressure of 0.5 mmHg per 1 °C increase in room temperature .*
> *and systolic blood pressure (—0.38mmHg/°C; P< 0.001) and diastolic blood pressure (—0.18mmHg/°C; P<0.001). There were similar, although non-significant, associations in the NTS*

This abstract of this paper reported:

> ***No s**ignificant associations were found between blood pressure and room temperature in either study after taking account of town blood pressure differences, nor between blood pressure and outdoor humidity in the NTS*

The WHO appears to have misrepresented this paper. The relationships the WHO reported were not significant. This should have been reported.

The WHO report concludes with an assessment of the strength of the evidence.

> *The certainty of the evidence that warming a cold house (to a minimum indoor temperature of 18°C) would reduce the risk of cardiovascular mortality and morbidity was assessed as moderate*.

Apparently the WHO's definition of 'moderate evidence' sets a very low bar. The only evidence was that there was some relationship between blood pressure and temperature for the elderly or the already ill. There was no evidence that this would have health consequences for the general population, or that an 18-degree threshold had any particular significance.

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[10] 222. Shiue I. Cold homes are associated with poor biomarkers and less blood pressure check-up: English Longitudinal Study of Ageing, 2012−2013. Environmental Science & Pollution Research International. 2016;23(7):7055−9.

[11] Bruce N, Elford J, Wannamethee G, Shaper AG. The contribution of environmental temperature and humidity to geographic variations in blood pressure. Journal of Hypertension. 1991;9(9):851−8.

Temperature adjustment by location

The 18-degree threshold is adjusted by an assessment of the most extreme external temperature that can could be experienced over the year in a particular local authority.   If that temperature is minus 2 degrees, then the heater must be capable of increasing the temperature in the lounge by 20 degrees to reach 18 degrees. A set of these temperature was determined by an analyst at the Energy Efficiency and Conservation Authority who measured the coldest hourly temperature recorded each year, for each territorial authority and averaged them over the years 1998-2018.   As the coldest hour in the year is the metric, the probability that the 18-degree temperature threshold will not be met is 1: 8760.

As the coldest part of the day is normally just around dawn, when there is a frost, this was not a suitable metric for setting a desired performance standard for a living room heating capacity standard. People are not sitting in the lounge at 6am to 7am. As a consequence, the temperature-increase requirements, and hence the size of the heaters have generally been set too high. The perversity of the threshold metric is illustrated by the standard for Wellington. The Wellington site doesn't have frosts, so with a minimum temperature of at plus two degrees is rated, along with Kaitaia, as the warmest site in the country. Wellington is rated as five degrees warmer than Kapiti, which is where Wellingtonians go for warmer weather.

Temperatures should have been recorded over the period (say 8am to 11pm) when living rooms are likely to be in use, and a number of thresholds for temperature shortfalls considered. It is not necessary to select a zero-shortfall target. A temperature shortfall of one or two degrees below 18 degrees for a short period does not have health consequences. At worst a shortfall will just prompt the occupant to put on more clothing or grab a rug. A lower temperature than desired can readily be mitigated (the stove will raise the temperature while in operation and can be left on for a few hours in a particularly cold snap, or a cheap fan heater can supplement the main heating source.

For example, the shortfalls could have been set at zero, 25 (0.45 percent of the time of possible occupancy) or 50 hours, and the temperature outcomes calculated. At the least the data should have been reviewed, so the implications of different thresholds for the probability of meeting any heating target understood.

The NIWA 'peer' review

An analysis by the Energy Efficiency and Conservation Authority (EECA) was 'peer reviewed' by the National Institute of Water and Atmospheric Research (NIWA) who just avoided the main issue by saying EECA were the 'experts' and did not review the logic of their model. NIWA should have pointed out that an absolute minimum daily temperature metric was not suitable for calibrating a regime intended to operate in the daytime and evenings.

> *We started by accepting the EECA methodology as a reasonable way of capturing 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 they (sic) may influence the heating requirements of rental homes.*

NIWA confined themselves to comparing the EECA temperature analysis to a different data set and concluded that the selection of temperature reading stations did not make an appreciable difference. It noted that the EECA analysis used a single design temperature per local authority and that this will not work well when there is more than one climatic zone within the authority's boundaries.

The heating capacity formula

The required heating capacity for a living room is determined by the formula set Schedule 2. of the regulations.

The full required capacity formula, set out in the appendix, looks complicated, but mostly relies on some simple principles. The heater has to have the capacity to meet both transmission heat loss and ventilation heat loss under the external temperature set for by each defined locality. It is calculated using the following formula:

$$h = [t + v + (f \times 40)] \div 1000$$

where—

h is the required heating capacity for the living room (kW)

t is the transmission heat loss of the living room (W) calculated under clause 3

v is the ventilation heat loss of the living room (W) calculated under clause 4

f is the area of the floor of the living room (m^2).

Transmission heat loss

This formula is lengthy but it is simply an add up of the heat losses from the living room's external thermal envelop, and the internal walls, determined by the R-values of the building elements. The heat losses though the internal walls are assumed to be half that though the external walls.

Ventilation heat loss

This is a measure of the amount of heating capacity that goes into heating the air drawn from the environment as warm air is lost from the living room. It is calculated by the volume of the room times the energy required to heat the new air. It is assumed that the air in the living room is turned over once an hour. There is no analysis to show that this is a reasonable assumption but it is unlikely that homeowners would be airing the living room on the coldest hour of the year.

The 'floor area' metric

The transmission and ventilation losses are intuitive. But there is no explanation for the term (f x 40). f is the floor area, but this is already taken into account in the calculation of the transmission and ventilation heat losses. The impact on the required heating capacity is material. With a 20 square metre floor area the additional heating requirement is (20 x 40)/1000 = 0.8 Kw. Table one shows the contribution of the formula components for an illustrative 20 square metre living room. The 'floor area' factor increases the heating capacity requirement by about 30 percent.

There is no supporting documentation for this 'floor space' requirement. The response by Associate Housing Minister Poto Williams to a request for this information under the Official Information Act was to refuse it because 'the policy documents that explain the theoretical basis for the model and the calibration of the inputs do not exist'.

We found it quite extraordinary that there was no policy document explaining the formula that is at the heart of the heating requirement.

We discussed the 'floor space' requirement with a Tenancy Services policy analyst. He was unable to offer an explanation for the requirement, though he admitted that it did not appear to make sense. He initially suggested that since the regulations had been approved by Parliament, we should contact our member of parliament for an explanation. The notion that an MP would know this technical detail, when the responsible Ministry doesn't, is of course, absurd.

We think the explanation for the insertion of this variable into the formula is clear. MBIE appears to have been on a 'mission' to force heat pumps on landlords without much regard to whether this was economic or whether heat pumps are an efficient solution for some smaller living rooms. It looks like someone slipped the additional variable in, probably hoping no-one would notice. MBIE was apparently careful not to commit anything to paper and did not have the formula peer reviewed.

Table one: Contribution to heating capacity –Hastings 20 sq. m. living room

Contribution source	Kw
Transmission	2.33
Ventilation	0.27
f x 40	0.8
Total	3.40

BRANZ 'peer review'

The Building Research Association of New Zealand (BRANZ) was engaged to compare the capacity calculated using the heating tool with the calculation obtained manually using the formula. Five houses or apartments in Wellington and the Hutt valley were compared. This was a minor, mostly arithmetic, test and it is not clear why BRANZ were restricted to just that task. We would have expected BRANZ to have peer reviewed the formula.

No testing of the formula

The predictive capacity of the heating model could have been tested empirically but this was not done before the regulations were introduced. In response to the request for information, the Associate Housing Minister Poto Williams explained that the reason the model could not be tested was that it was not possible to wait until the weather was cold enough to conduct a test. This conveys a lack of understanding of how the formula works. It is not the absolute external temperature that matters, but rather the temperature difference between the external and internal temperature. If a 20-degree difference is required, this can just as well be tested with a 10-degree external temperature, with a 30 degree internal target, as a minus 2 degree external temperature and an 18 degree internal target.

Standard heater or heat pump

The heating capacity calculation will determine whether a standard heater with a capacity of up to 2.4 kw will suffice, or whether a heat pump has to be installed. These cutoffs are very low. In the Hastings district, for older (pre 1978) homes, a heat pump is typically required when the living room is greater than 12 square metres. In the Mackenzie District the cut off is about seven square metres.

Heat pumps may not function effectively in small rooms and may not be used by tenants. It a heat pump is oversized for the room 99 percent of the time, it will operate less efficiently and will have a shorter service life.

Determining the capacity of the heater

There is no legal requirement, in the regulations, for determining the capacity of a heater. However, there is the following discussion in the Healthy Homes Heating guidance document.

> *For heat pumps, a standardised heating capacity must be stated on the labels of heat pumps sold in New Zealand. This represents the heat pump capacity when tested at 7˚C. Where a heat pump range is provided on a label as well as the heat pump capacity, the capacity measure should be used and not the range measure, as the range is not reliable as a measure for consistent output of heating capacity.*
>
> *Sometimes a label will provide a measure for both a 'Capacity kW', showing nominal heating capacity, and 'Capacity (Range) kW'. In these situations, the nominal heating capacity should be used to select the device, not the capacity range.*

If the landlord believes that a heat pump range is the appropriate measure then it appears that this can be used as there is no legal force to Tenancy Service's advice.

> *Information for assessing the heating capacity of a wood burner can usually be found on the label of the wood burner or its consenting records. Where multiple capacities are listed on the label, it is best to rely on the highest average output, but not the peak output. The peak output is not suitable as it does not represent consistent output.*

Similarly, the landlord should be able to use the peak output. As the heating capacity requirement is calibrated off the coldest hour of the year, consistent output is not a requirement to meet the temperature test. The fire just has to be stoked up to meet the standard for one hour.

In the Tenancy Services website discussion on the heating tool there is the following:

> *You need more heating capacity if you live somewhere cold. Some heat pumps struggle to perform at cold outdoor temperatures just above freezing point. If you live somewhere cold and your heaters include a heat pump, you'll need one that performs well at cooler temperatures*

As the standard is calibrated to temperature that are below or just at freezing, most rentals will be 'somewhere cold' and this advice could be read as a requirement that landlords should purchase heat pumps that (claim to) maintain their heating capacity at very low temperatures, or install an even larger capacity heat pump that will generate the 'right amount' of heat at the designated external temperature. Landlords can ignore this advice if they wish.

Tolerance for existing heating

If a heater was installed before 1 July 2019, the heating capacity requirement is 90 percent of the requirement determined by the formula. Presumably, this was to provide some relief to landlords who installed a heater in good faith and on supplier or professional advice that was adequate for the size of the room. As the 10 percent reduction is substantially less than the artificial increase inserted into the formula by unknown parties, this will not provide any benefit for many affected landlords. They will still have to incur the expense of an unnecessary upgrade.

> *This tolerance only applies to heating devices installed before 1 July 2019. Therefore, as soon as a device is replaced, it must be replaced by a device that meets all the requirements of the heating standard. Any heater installed after 1 July 2019 should meet the heating standard requirement in readiness for the Healthy Homes Standards compliance date.*

Using electric heating to 'top up' existing heating

The standard allows an electric heater to be used to top-up an existing heat pump providing:

- The existing heating was installed before 1 July 2019;
- And the top-up required is less than 1.5 kW.

It is difficult to understand the logic behind the 1.5 kw. top-up limit. A 2.4 kw allowance would mean that fewer landlords would have to install an additional expensive heat pump. Presumably, the thinking here was that electric heaters are expensive to operate, compared to a heat pump and Tenancy Services wanted to restrict their use. What this misses is that the top-up heater would only be needed to be used infrequently (if at all) to meet the 18 degree standard, so the additional operating cost would be very small. For example, assume that the top-up heater was used 20 hours a year during the most extreme of cold snaps. The additional heating cost (assuming the heat pump is twice as efficient as the electric heater) would be about $3. The landlord could incur a capital cost of about $3000, plus annual servicing costs, to save that $3. Even if the heater was used five times as much, the running cost savings would still be only $15. These costs will eventually be passed on to tenants.

Heating tool and the age of the property

The heating tool provides an easy-to-use methodology, that primarily requires just the input of the age of the building and the dimensions of the living room, its windows, and the ceiling structure. The building age inputs a set of R-value inputs as default values. The user can adjust those values if the building has different R values than those typical of a building of its age.

The output is the required capacity of the living room heater in terms of kilowatts. Table one gives a set of requirements by building age for a living room with the following common characteristics.

Location: Hastings -2 degrees external temperature
Height of walls: 2.4m.
External wall lengths: 4 and 5 m.
Internal walls lengths: 4 and 5 m.
Floor area: 20 sq. m.
Window area: 4 sq.m.
Flat ceiling

The capacity requirements fall as changes to building standards have increased average R values over time. Note, however, that there was no improvement from the 2009 standards. This probably reflects roundings in the heating tool calculator, but it suggests that the 2009 insulation changes made little difference, at least according to be model, which may not perfectly replicate the real world.

Table two: Capacity requirements and building age

Age	Capacity requirement kw.
1977 and earlier	3.4
1978 -2000	3.1
2001-2008	2.9
2009 and later	2.9

Conclusion

A heating assessment tool should be a useful aid, not only tenants and landlords, but for homeowners and others with an interest in home heating. However, the existing heating tool is flawed.

The external temperature for the capacity test is set at the coldest hour of the year, around daybreak, rather than reflecting temperatures when living rooms are actually in use.

The heating formula appears to have been deliberately manipulated to increase the heating requirement. There was no documentation; no real-world tests were carried out to check the formula, and there was no genuine peer review of the Ministry's analysis. As a consequence, heating capacities are typical set 30 percent or more higher than they should be. Heat pumps are being required in small rooms where they are not economic and technically efficient. Landlords will be required to install additional heat pumps in rooms that are already been adequately served by heaters installed after professional advice.

The argument that heating requirements should be more conservative because this is a health issue does not hold water. There is no evidence that temperatures of just under 18 degrees has any effect only people in reasonable health, particularly if it occurs just for a few hours a year in cold snaps.

The Associate Minister should go back to the drawing board and instruct MBIE to create an accurate and credible heating assessment framework. The heating formula in the regulations should be immediately changed to remove the 'floor area' adjustment.

Appendix 1 The heating capacity formula

(1) The transmission heat loss of a living room is to be calculated using the following formula:

$$t = [\, d + (e \times g) \,] \times (b - c)$$

where—

t is the transmission heat loss of the living room (W)

d is the transmission heat loss in respect of the living room's building elements that are part of the tenancy building's thermal envelope (W), calculated under subclause (2)

e is the transmission heat loss in respect of the building elements that form the boundaries of the living room but are not part of the building's thermal envelope, calculated under subclause (3)

g is the temperature adjustment factor for building elements that are not part of the tenancy building's thermal envelope, being 0.5

b is the required internal temperature, being 18°C

c is the assumed external temperature for the premises as set out in clause 5.

(2)
The value of d is to be calculated using the following formula:

$$d = \sum_j (A_j \div R_j) + \sum_k (A_k \div R_k) + \sum_m (A_m \div R_m) + \sum_n (A_n \div R_n) + \sum_p (A_p \div R_p)$$

where—

d

is the transmission heat loss in respect of the living room's building elements that are part of the building's thermal envelope (W)

A_j

is the area of ceiling j (m^2)

R_j is the construction R-value of ceiling j (°Cm^2/W)

J is the numbering index for all of the living room's ceilings that are part of the building's thermal envelope.

A_k is the area of wall k (m^2)

R_k is the construction R-value of wall k (°Cm^2/W)

K is the numbering index for all of the living room's walls that are part of the building's thermal envelope

A_m is the area of floor m (m^2)

R_m is the construction R-value of floor m (°Cm^2/W)

M is the numbering index for all of the living room's floors that are part of the building's thermal envelope

A_n is the area of window n (m^2)

R_n is the construction R-value of window n (°Cm^2/W)

N is the numbering index for all of the living room's external windows

A_p is the area of skylight p (m^2)

R_p is the construction R-value of skylight p (°Cm^2/W)

P is the numbering index for all of the living room's skylights.

(3) The value of e is to be calculated using the following formula:

$$e = \sum_{q}(A_q \div R_q) + \sum_{s}(A_s \div R_s) + \sum_{u}(A_u \div R_u)$$

where—

e is the transmission heat loss in respect of the building elements that form the boundaries of the living room but are not part of the building's thermal envelope (W)

A_q is the area of ceiling q (m^2)

R_q is the construction R-value of ceiling q (°Cm^2/W)

Q is the numbering index for all of the living room's ceilings that are part of the boundary of the living room but are not part of the building's thermal envelope

A_s is the area of wall s (m^2)

R_s is the construction R-value of wall s (°Cm^2/W)

S is the numbering index for all the living room's walls that are part of the boundary of the living room but are not part of the building's thermal envelope

A_u is the area of floor area u (m^2)

R_u is the construction R-value of floor area u (°Cm^2/W)

U is the numbering index for all of the living room's floors that are part of the boundary of the living room but are not part of the building's thermal envelope.

(4) For the purposes of subclauses (2) and (3), if a ceiling, wall, or floor consists of 2 or more areas that have different construction R-values, each of those areas is taken to be a separate ceiling, wall, or floor.

4 Ventilation heat loss

The ventilation heat loss of a living room is to be calculated using the following formula:

$$v = w \times y \times z \times (b - c)$$

where—

v is the ventilation heat loss of the living room (W)

w is the internal volume of the living room (m^3)

y is the assumed air change rate of the living room, being 1.0

z is the assumed value for the density of air multiplied by the specific heat of air, being 0.34 Wh/m^{3}K

b is the required internal temperature, being 18°C

c is the assumed external temperature for the premises as set out in clause 5.