Study report: SR502 [2025]

# Household Energy End-use Project 2:

## Report on summer comfort, cooling and indoor temperatures (preliminary analysis)

Ben Anderson, Vicki White, Suzanne Jones, Aidan Bennett-Reilly, Manfred Plagmann, Andrew Pollard

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- over 750 households that took part in the national study in some capacity.

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## BRANZ Study Report SR502

## Authors

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## Reference

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## Abstract

The Household Energy End-use Project 2 (HEEP2) is a comprehensive national study of energy use and conditions in New Zealand homes designed to replicate the earlier HEEP study (HEEP1) undertaken in 1999–2005. HEEP2 involves a national sample of over 750 households with data collected in various ways, including self-completion and on-site surveys, in-home monitoring, and accessing metered energy data from retailers. This report presents preliminary insights from some survey and monitoring data, looking at occupant comfort and internal temperatures in summer. The survey data is derived from the in-home interview and building and appliance survey completed for 425 households throughout the country. The temperature analysis is based on a subset of 151 of these households monitored over summer 2023/24. All results are unweighted, and the monitoring data comprises only around half the HEEP2 monitored sample. These results are therefore indicative and preliminary only.

The survey indicated that around 70% of respondents experienced warmer indoor conditions than desired at least some time in summer. Around 1 in 5 respondents stated that this was always or often. These proportions are higher than those who reported their home was colder than they would like in winter (based on the same HEEP2 survey and sample). Of those households that had a heat pump or air conditioner, 18% reported using it every day or most days to cool their room(s) in summer (13% of the total sample). Overall, 72% of households with a heat pump or air conditioner (52% of the total sample) reported using it at least some time in summer, even if on rare occasions.

Preliminary analysis of temperature data for the 151 households monitored over summer 2023/24 suggests the average temperature in living rooms and bedrooms are similar throughout the day, being warmest in the evenings at around 24°C. Almost half of living areas were above 25°C at 6pm, and 25% of bedrooms were over 24°C at 2am.

A preliminary comparison of the HEEP2 summer 2023/24 subset with HEEP1 (1999–2005) suggests an increase in both external and internal temperatures. Analysis of overheating in bedrooms using the industry standard CIBSE 1b criteria showed that for this subsample of HEEP2 homes, 36% of the 310 monitored bedrooms in summer

2023/24 were classed as overheating. This rose to 58% of the 45 Auckland bedrooms but was only one of the 29 Wellington bedrooms monitored.

The results reported in this paper are intended to provide illustrative and preliminary analysis of some of the data being collected in the HEEP2 study. Future work with the complete HEEP2 dataset will extend this analysis to provide a more detailed understanding of the factors affecting indoor summer temperatures and the risk of overheating.

## Keywords

Energy use, indoor temperatures, summer, comfort, overheating

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# Executive summary

The Household Energy End-use Project 2 (HEEP2) is a comprehensive national study of energy use and conditions in New Zealand homes. Building on the foundational HEEP study (HEEP1) conducted from 1999 to 2005, HEEP2 aims to provide updated insights into household energy consumption and indoor environmental conditions in the early 2020s.

Households were recruited to the national HEEP2 study through the Stats NZ Household Economic Survey (HES) 2021/22, with additional recruitment through the 2023/24 HES. All household types and typologies were eligible to take part. Over 750 households are taking part in some capacity.

The HEEP2 data collection includes combinations of self-completion and on-site surveys, in-home monitoring and accessing metered energy data from retailers.

This report presents preliminary results, focusing on summer comfort and internal temperatures in homes. It draws on data from an in-home interview and building and appliance survey completed for 425 households. The preliminary analysis of internal temperatures uses a subset of this national sample comprising 151 households that were monitored over summer 2023/24.

All results reported here use unweighted data. Temperature monitoring data comprises a subset of the HEEP2 monitored dataset. These results must therefore be considered preliminary only. Similar analyses will be undertaken and reported using the complete and final dataset.

## About the sample

- Households in the HEEP2 national sample are predominantly owner-occupied. HEEP2 respondents are slightly older and have slightly higher incomes compared to the national population. The regional spread reflects the national dwelling distribution with some exceptions due to fieldwork challenges (namely Tasman and Gisborne).
- The dwelling type and size of houses in the HEEP2 sample is consistent with previous national housing surveys with most homes being stand-alone single-storey dwellings.
- The building age distribution roughly aligns with other data, though there are possibly slightly fewer houses built pre-1920 and post-2000 in the HEEP2 sample.

## Occupant comfort in summer and keeping cool

- Approximately 70% of the 425 respondents who completed an in-home interview reported their homes being warmer than desired at least some of the time during summer. For 22% of these, this was always or often warmer.
- The proportion of householders reporting their homes warmer than they would like in summer was higher than the proportion reporting their homes colder than they would like in winter – 14% always or often, 34% at least some of the time (Anderson et al., 2024).
- Younger respondents and those living in smaller houses were more likely to say that their house was always or often warmer than they would like in summer.
- Active cooling of living areas using heat pumps or air conditioners at least some time in summer was reported by 52% of all households, with 13% reporting using these every day or most days. Excluding those that did not have a heap pump or air conditioner, these proportions increase to 18% cooling their living area every

day or most days, 24% some days and 30% hardly ever. This equates to 72% actively cooling the living area at least some time in summer, even if on rare occasions.
- The rate of cooling of bedrooms and other areas of the home for HEEP2 households is lower, largely due to a lack of an appliance to do so. Overall, fewer than 1 in 20 households (3% of the sample) reported cooling bedrooms every day or most days. This increases to 13% cooling bedrooms, if those without cooling appliances in these rooms are excluded.
- Respondents in older age groups were less likely to report using their heat pump for cooling as were those in the lowest income bracket.
- Households were asked if they regularly did any other things to help keep their home cool in summer. Leaving windows open all day and opening doors and windows to create a cross-breeze were common behaviours among survey respondents, with around 4 in 5 households doing these things. Closing curtains/blinds and using electric fans were reported by around half of households. Using a heat pump on a fan setting and using external shading like awnings or louvres was infrequent in this sample.

**Indoor temperatures**
- Preliminary analysis of data from a subset of HEEP2 homes (151) monitored over summer 2023/24 (December to February) indicates the average temperature in living rooms and bedrooms were similar across the day, being warmest in the evenings at around 24°C.
- Almost half of living areas were above 25°C at 6pm, and 25% of bedrooms were over 24°C at 2am.
- A preliminary comparison of the HEEP2 summer 2023/24 subset with HEEP1 (1999–2005) suggests an increase in both external and internal temperatures. The average evening temperature reported in HEEP1 in living areas was 23.1°C compared to 24.4°C in HEEP2. The average night-time temperature in bedrooms reported in HEEP1 was 20.1°C compared to 22.2°C for the HEEP2 subset. These results are indicative due to differences in the regional distribution of the HEEP2 summer 2023/24 subsample and the HEEP1 sample. This analysis will be repeated with the complete set of HEEP2 monitoring data when available.
- Preliminary analysis of overheating in bedrooms using the industry standard CIBSE 1b criteria showed that 36% of the 310 monitored bedrooms in the HEEP2 summer 2023/24 sample were classed as overheating according to this methodology. This rose to 58% of the 45 Auckland bedrooms but was only 3% (one) of the 29 Wellington bedrooms monitored.

## Conclusions and future work

- The results reported in this paper are intended to provide illustrative and preliminary analysis of some of the data being collected in the HEEP2 study.
- The survey results presented give an indication of householder experiences of comfort in their homes over summer and actions taken to keep the home cool.
- Preliminary analysis of internal temperatures for the partial HEEP2 summer 2023/24 sample showed expected differences across regions and indicate a potential increase in mean internal temperatures since the original HEEP study.
- Future work with the complete HEEP2 dataset will extend this analysis to provide a more detailed exploration of the factors affecting indoor summer temperatures and the risk of overheating.

# 1. Introduction

The Household Energy End-use Project 2 (HEEP2) is a national study of energy use and conditions in New Zealand homes. It was designed to closely replicate HEEP, a similar study undertaken in 1999–2005 (HEEP1). HEEP1 provided critical evidence and insights into indoor temperatures and the proportion of energy that households used for different services (heating, hot water, lighting, cooking and plug loads). The HEEP1 data, results and insights are still in use despite significant change since the study was undertaken. This includes changes to housing itself – through changing building practices/Code and retrofitting – as well as changes to appliances in the home (such as a shift towards more efficient modes of heating, cooling and lighting like heat pumps and LEDs). HEEP2 aims to provide an up-to-date picture of conditions and energy use in homes in the early 2020s by collecting data through self-completion and on-site surveys, in-home monitoring and by accessing metered energy data from retailers.

## 1.1 Sample recruitment and data collection

As described by Anderson et al. (2024), households were recruited to the national HEEP2 study through the Stats NZ Household Economic Survey (HES) 2021/22, with additional recruitment through the 2023/24 HES.

The HEEP2 national study comprises a nested sample approach, with 'tiers' of data collection ranging from remote (self-complete) surveys, through onsite interviews and building surveys, to intensive in-home monitoring. These HEEP2 study groups are referred to as Light, Medium and Full, reflecting the amount of data collected as described in Figure 1. Further information on the full range of data collected is provided in the HEEP2 Data Catalogue, available on the BRANZ website.[1]

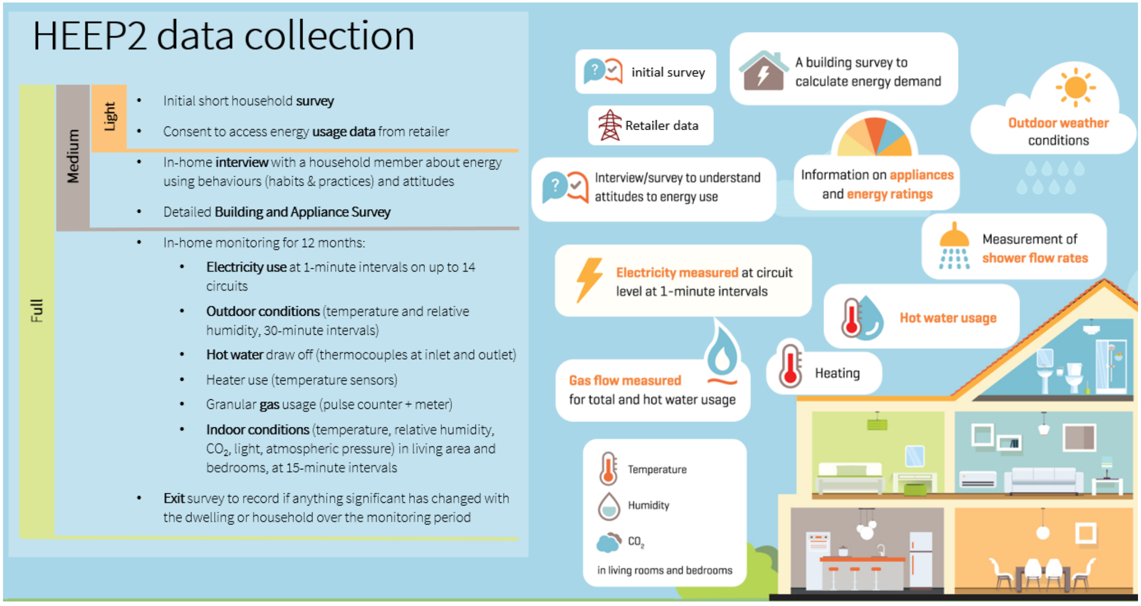


**Figure 1. Overview of data collected in HEEP2.**

[1] https://www.branz.co.nz/healthy-homes-research/heep2-energy-use-living-conditions-in-nz-homes/information-for-researchers/

## 1.2 About this report

The design and construction of a home will affect its propensity to overheat in summer and become uncomfortably warm for occupants. Details such as window area, framing and glazing type, orientation, presence of external shading and ventilation all contribute to overheating risk. Location (regional climate or even local microclimate) is also a key factor. The risk of summertime overheating is likely to increase with a warming climate. A growing reliance on active cooling through mechanical ventilation or air conditioners (reverse cycle heat pumps) would have significant implications for household energy use and summertime peak demand on the electricity grid.

This report presents insights from HEEP2 on behavioural and dwelling characteristics related to perceptions of overheating alongside data from indoor monitoring of a subset of houses. The first part draws on survey data from the Full and Medium samples (425 homes), presenting insights from the householder interview on cooling behaviours and comfort in summer, followed by data from the building survey, focusing on dwelling characteristics known to relate to increased risk of overheating. Results from indoor temperature sensors in a subset of the Full houses monitored over summer 2023/24 are then presented to give an indicative update on the HEEP1 internal temperature results.

The building surveys and householder interviews are snapshots in time, collected at the beginning of each household's involvement in the project. This data is considered complete although is subject to further cleaning and (re)coding as analysis progresses and/or missing data is infilled.[2] This may result in small changes to counts and percentages in future reports. All results reported here also use unweighted data. The final HEEP2 dataset may be subject to weighting.

The monitoring data, which is limited to the subset of Full houses that were monitored over summer 2023/24 (n=175) and for whom clean data coverage was at least 95% (n=151), is neither final nor complete.

As the monitoring data presented here covers around half of the HEEP2 Full monitored dataset and all data is unweighted, these results must be considered preliminary. Similar analyses will be undertaken and reported using the complete and final dataset.

## 1.3 HEEP2 sample characteristics

Regional and socio-demographic characteristics of the Full and Medium samples (combined) are presented in Anderson et al. (2024). To summarise:

- the HEEP2 sample has good regional representation, with surveying undertaken in all regions except Gisborne and Tasman (due to access and technical limitations at the time of field work)
- the sample is predominantly owner-occupied households, with only 6% being renters
- two-fifths (43%) had lived at their current home for more than 10 years and a quarter had lived there for 5–10 years
- over two-thirds of survey respondents were aged 65 or over, suggesting a slight bias towards older age groups

The HEEP2 sample comprises mostly owner-occupied households, with a slight bias towards older age groups.

[2] Missing data from the surveys, though limited, is being collected at the time of removal of monitoring equipment, hence some further updates to these datasets are likely.

- half of survey respondents were in full-time employment while a third (34%) were not in the labour force (reflecting the older, retired age profile of the sample)
- around one-fifth (19%) of the HEEP2 sample had a household income of $50,000 or less, while around a quarter had an income of $150,000 or more (the former being proportionally lower and the latter higher than Census estimates)
- dwelling types, size and age are reasonably consistent with other national data sources, suggesting good representation across these parameters.

# 2. Survey results

## 2.1 Comfort and cooling behaviours

HEEP2 householder survey respondents were asked about the comfort of their homes during summer, their frequency of using air conditioners for cooling and other things they might do to help keep cool in summer. The results reported here use the complete sample of Full and Medium households surveyed but are unweighted and may therefore be subject to change in future analysis.

### 2.1.1 Summer comfort

1 in 5 householders reported their home always or often warmer than they would like in summer.

The householder survey asked respondents if they ever found their home warmer than they would like in summer. The results show more than 1 in 5 (22%) reported their home was always or often warmer than they would like in summer, and an additional 48% reported it sometimes warmer (Figure 2). Combined, this equates to around 70% of respondents finding their home warmer than they'd like at least some time in summer. This is higher than the proportion of households who reported their home colder than they would like in winter, with 48% stating it was colder than they would like at least some of the time and 14% reporting it always or often colder (Anderson et al., 2024).

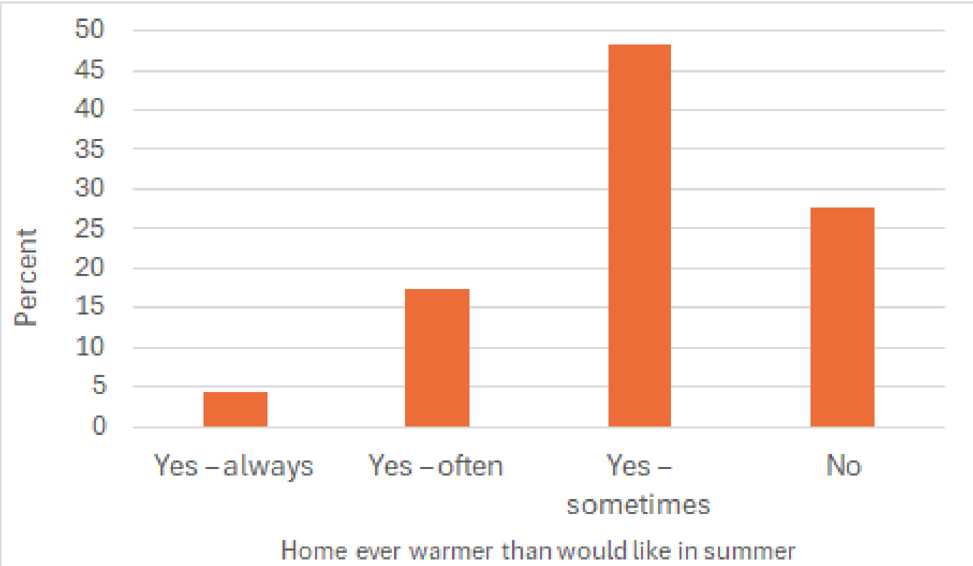


**Figure 2. Home ever warmer than the respondent would like.**

In the HEEP2 survey sample, younger respondents were more likely to report their home being warmer than they would like in summer. For example, 49% of those aged 25–34 said their home was always or often warmer than they would like, compared to 13% of those aged 65 or over (Figure 3). There was little difference by income group but some variation by region, not necessarily as expected. Survey respondents in the Wellington region were more likely to report their home always or often warmer than they would like in summer (29%) compared to Auckland (24%) and Canterbury (14%) regions. There will be a wide range of factors underlying these observations – for example, dwelling characteristics, householder preferences and the householder's ability to cool the home – some of which will be explored in future analyses.

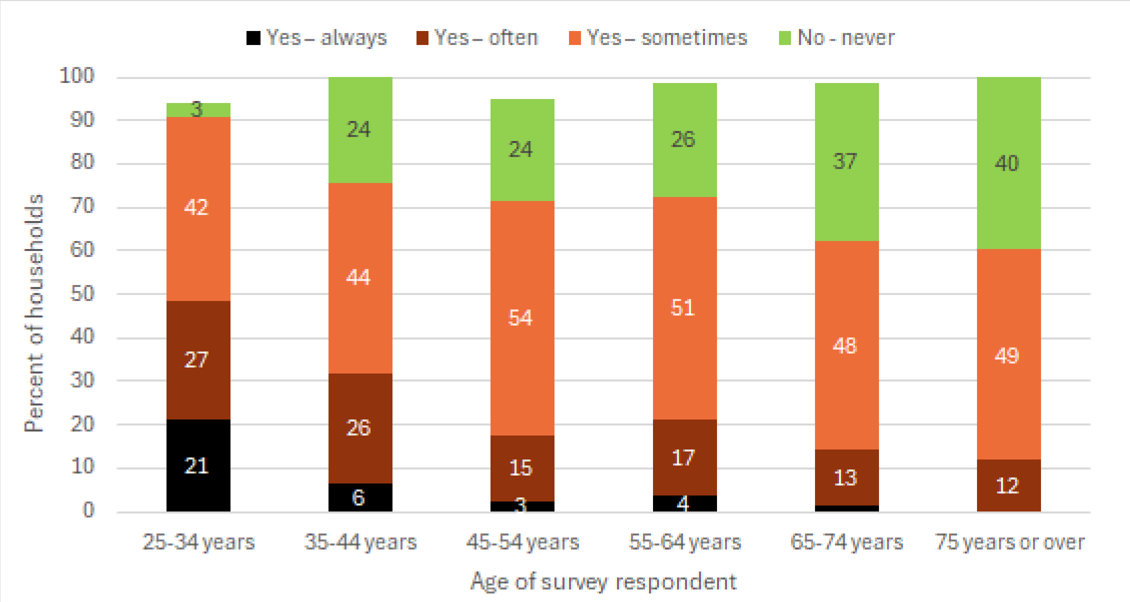


**Figure 3. Home ever warmer than the respondent would like by age of respondent.**

## 2.1.2 Keeping cool

### Active cooling

Households were asked how often they use a heat pump or air conditioner (AC) (including ducted systems) for cooling different areas of the house, differentiating living areas, bedrooms and other rooms/areas.

Where a heat pump or AC was not available to cool the room, the response should be 'N/A no heat pump/air con unit' as opposed to 'never'.[3] These results are based on an initial quality check of this data, but some further refinement may be required, so numbers are subject to change slightly in future reporting.

The results suggest that, overall, around 1 in 8 households (13%) actively cooled their living area(s) every day or most days in summer, with an additional 17% reporting cooling on some days (Figure 4). Including those who responded hardly ever (but therefore at least of the time) suggests just over half (52%) of households surveyed use their heat pump or AC for cooling at some time.

Excluding households that did not have a means to actively cool the main living area (no heat pump or AC system present), these percentages increase to 18% cooling every day or most days, 24% some days and 30% hardly ever, which equates to 72% actively cooling at least some time in summer, even if on rare occasions.

18% of householders with a heat pump reported using it to cool their main living area every day or most days in summer.

[3] This data required some cleaning and cross-checking with information from the building survey and other sources such as electricity circuits to confirm if a cooling appliance was in fact present.

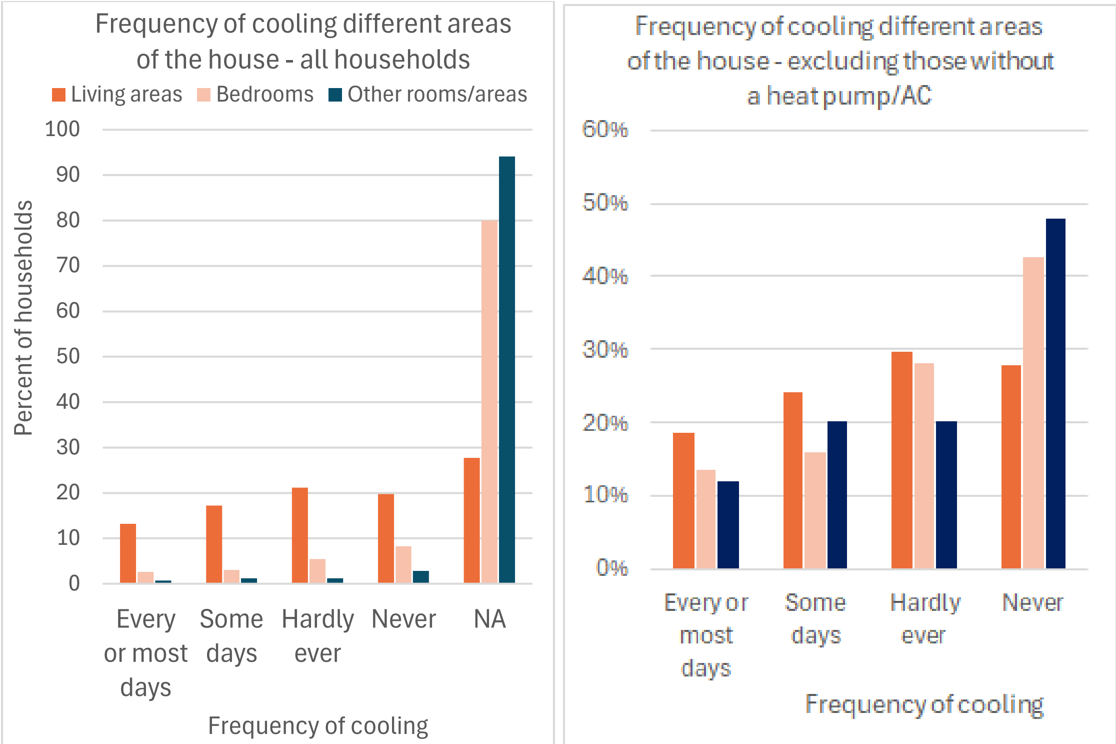


**Figure 4. Frequency of active cooling in different rooms of the house where NA indicates no cooling appliance in the room/area (left) and frequency of cooling excluding those without a heat pump/AC system (right).**

Overall, 72% of households with a heat pump used it for cooling at least some time in summer.

These results are comparable to a 2021/22 study that surveyed households living in areas that often experience hot summer temperatures (O'Sullivan, 2024). They are, however, lower than those reported in an earlier BRANZ study (Burrough et al., 2015). The 2021/22 survey showed that, of those who had a heat pump, 72% were using these for cooling or air conditioning, while the 2015 study reported 58% of householders surveyed used their heat pump for cooling. The latter study also found that heat pump cooling behaviour was very fragmented compared to heating – the appliance was used for cooling intermittently with no discernible pattern for that sample.

The rate of cooling of bedrooms and other areas of the home for HEEP2 households is lower, largely due to a lack of an appliance to do so. Overall, fewer than 1 in 20 households (3%) reported cooling bedrooms every day or most days. This increases to 13% cooling bedrooms if those without cooling appliances are excluded. Including those who cooled on some days (16%) or hardly ever (28%) suggests 57% of households with a heat pump or cooling system used it to cool bedrooms at least some time in summer.

The initial survey results show that a similar proportion of households (52%) used their heat pump or AC system to cool other areas of the home, with 12% reporting cooling them every day or most days. Further analysis of heat pump use for cooling will be undertaken with the complete set of HEEP2 monitoring data.

There was a moderate correlation between the likelihood of actively cooling the main living area and feeling warmer than one would like in summer. Those who never felt their home was too warm in summer, never or hardly ever used active cooling in the main living area.

Looking at reported use of heat pumps for cooling the living area by age suggests those in the older age groups were the least likely to report cooling. Forty-three percent of those aged 75 or over never used heat pumps for cooling compared to 17–30% for all other age bands (Figure 5).

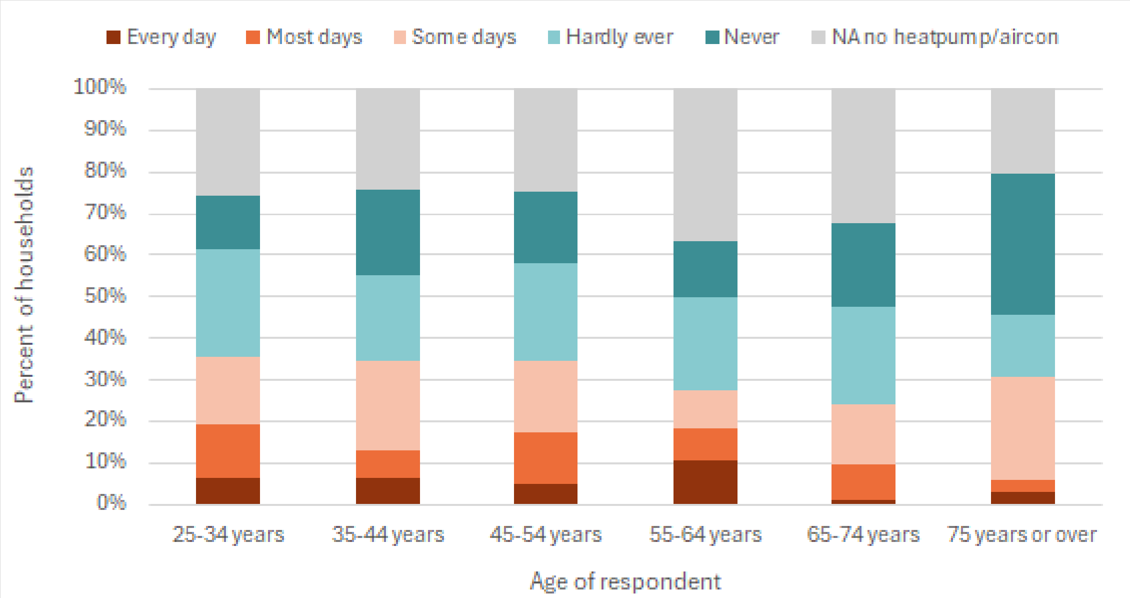


**Figure 5. Use of heat pump or AC for cooling the living area by age of respondent.**

The HEEP2 survey also shows that those in the $50,000 or less income bracket in this sample reported lower use of their heat pump for cooling compared to other income bands – 44% never compared to 17–27% for other income groups (Figure 6).

Respondents in older age groups and those in the lowest income bracket were less likely to report using their heat pump for cooling.

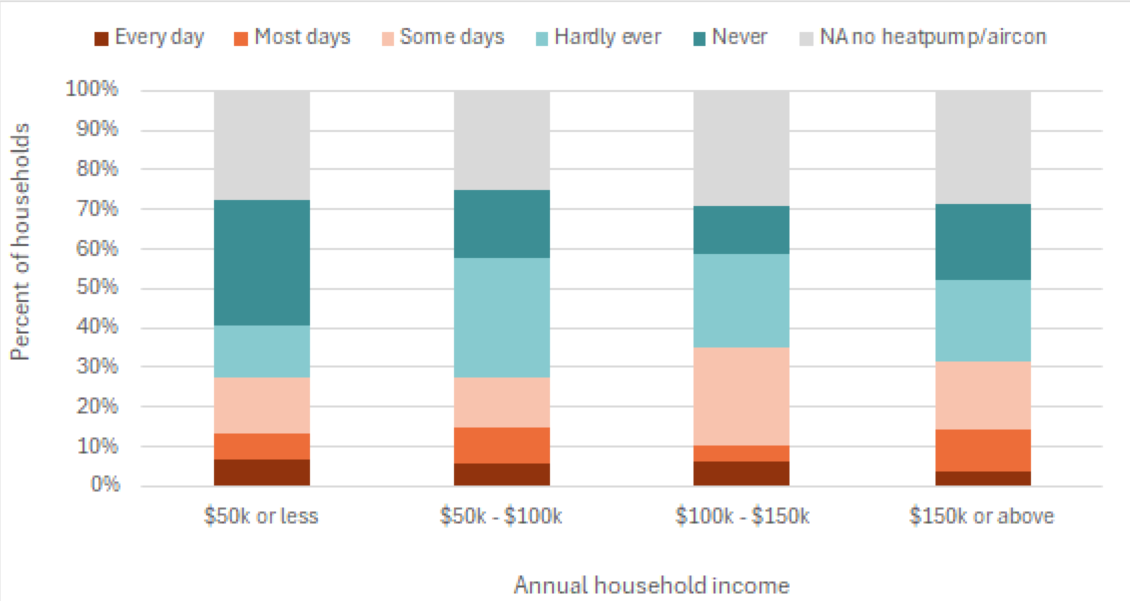


**Figure 6. Use of heat pump or AC for cooling the living area by household income.**

The reported frequency of actively cooling the main living area was fairly consistent across regions, although Northland, Auckland, Bay of Plenty and Waikato had higher rates of reported cooling compared to Canterbury, Manawatū-Whanganui and Wellington. This could be due to lower prevalence of heat pumps in houses in the latter two regions.

### Other ways of keeping cool

Households were asked if they regularly did any other things to help keep their home cool in summer, choosing from a prespecified list with the option of 'other'. The results show leaving windows open all day and opening doors and windows to create a cross-breeze were common behaviours among survey respondents, with around 4 in 5 households doing these things (Figure 7). Closing curtains/blinds and using electric fans were reported by around half of households. Using a heat pump on a fan setting was relatively infrequent. Further research could explore the extent to which householders are aware this functionality exists.

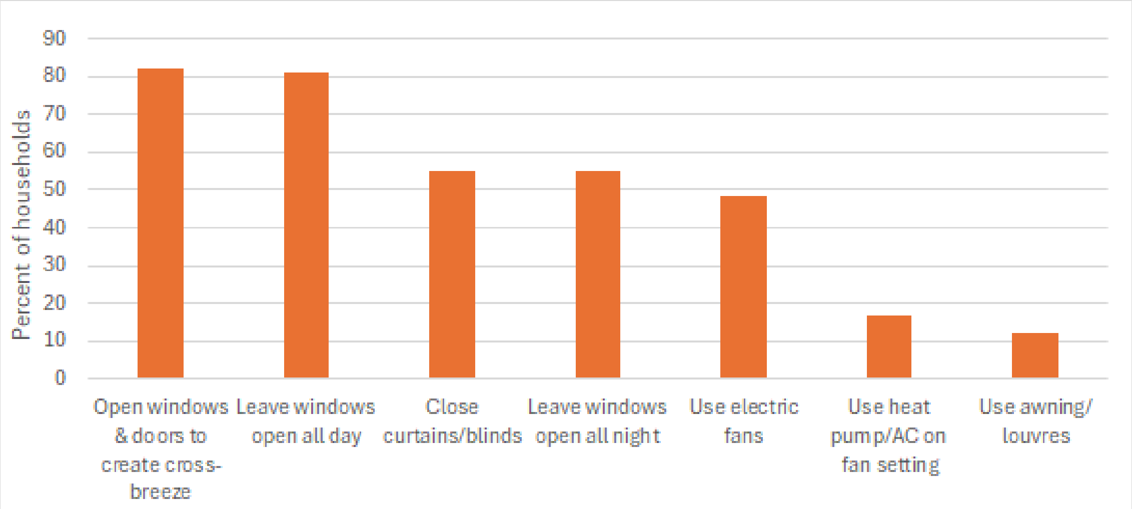


**Figure 7. Other things households do to help keep the home cool in summer.**

## 2.2 Dwelling characteristics

The design and construction of a home will affect its propensity to overheat and become uncomfortably warm for occupants in summer. Details such as window area, framing and glazing type, orientation, presence of external shading and ventilation all contribute to the risk of a house becoming too hot. Outdoor conditions and therefore geographic location are also important factors.

This section uses information collected in the building and appliance survey to explore relationships between some dwelling characteristics and the likelihood of a householder feeling warmer than they would like in summer.[4] For more information about the building features of the HEEP2 sample, see Anderson et al. (2024).

[4] A small number of houses are excluded from this section (~2%). They either did not respond to the relevant questions, responded 'don't know' or had not spent a summer living at the address at the time of the survey.

### 2.2.1 Dwelling size and type

Those in smaller houses were more likely to say that their house was always or often warmer than they would like in summer.

While around 1 in 5 householders responded that their house was always or often warmer than they would like in summer, this varied somewhat by the size of the dwelling. Those in smaller houses were more likely to say that their house was always or often warmer than they would like in summer – 32% compared to 18% in large houses and 19% in very large houses (Figure 8).

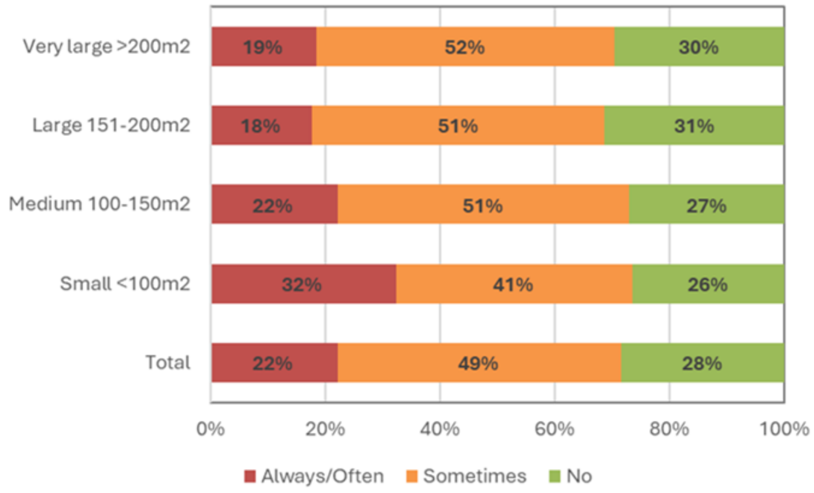


**Figure 8. House feels warmer than householder would like in summer by house size.**

Figure 9 shows the same information by the type of dwelling – whether a stand-alone house or joined to another dwelling/apartment. Survey respondents living in joined dwellings were slightly more likely to always or often feel warmer than they would like in summer (26% compared to 22% overall), but they were also the most likely to say they never feel warmer than they would like in summer (33% compared to 28% overall). Joined dwellings include single-storey and multi-storey houses and apartments/flats. Splitting these into their distinct categories suggests those living in apartments/flats or attached single-storey houses were the most likely to report their home being warmer than they'd like in winter although the former had only 12 respondents and will therefore be subject to large sample error.

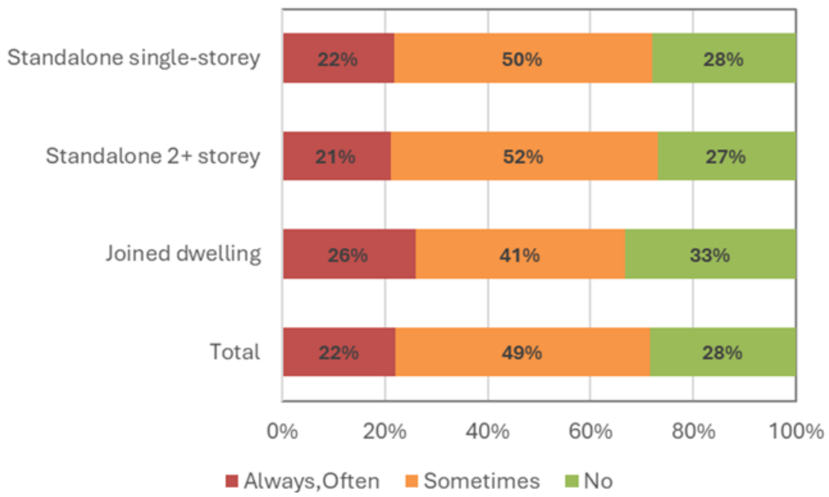


**Figure 9. House feels warmer than householder would like in summer by dwelling type.**

### 2.2.2 Glazing and orientation

Windows and doors can account for more heat gain or loss than any other element in a house's building envelope. The amount of glazing can and should vary by its orientation. For example, BRANZ recommends that the size of north-facing windows should be approximately 10-15% of the home's total floor area depending on the type of flooring in the house (Level, 2023). Glazing in rooms facing in other directions should be smaller – (3-5% of the total floor area). The average house level glazing ratio for the HEEP2 sample is 23%. Figure 10 shows the distribution of houses by grouped house level glazing to floor area ratio. Note that this data may also be subject to small changes as data quality checks continue.

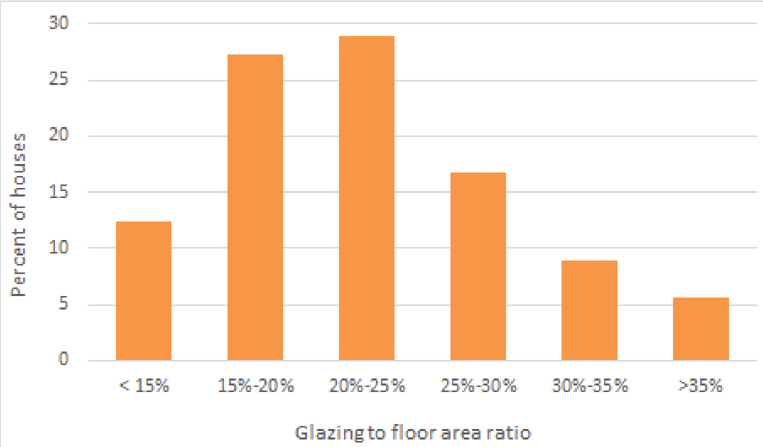


**Figure 10. Glazing to floor area for HEEP2 sample houses.**

As Figure 11 shows that, on average, smaller dwellings in the HEEP2 sample have higher glazing to floor area ratios, as would be expected. Dwellings with a floor area less than 100 m² had an average ratio of 26% compared to medium houses (100–150 m²) and large/very large houses (150 m² or more), with average ratios of 24% and 21% respectively. Further analysis indicated a weak relationship between the glazing to floor area ratio and the occupant feeling warmer than they would like in summer. Future analyses will look at the relationship between actual indoor temperatures and glazing (for example, to include orientation and eaves).

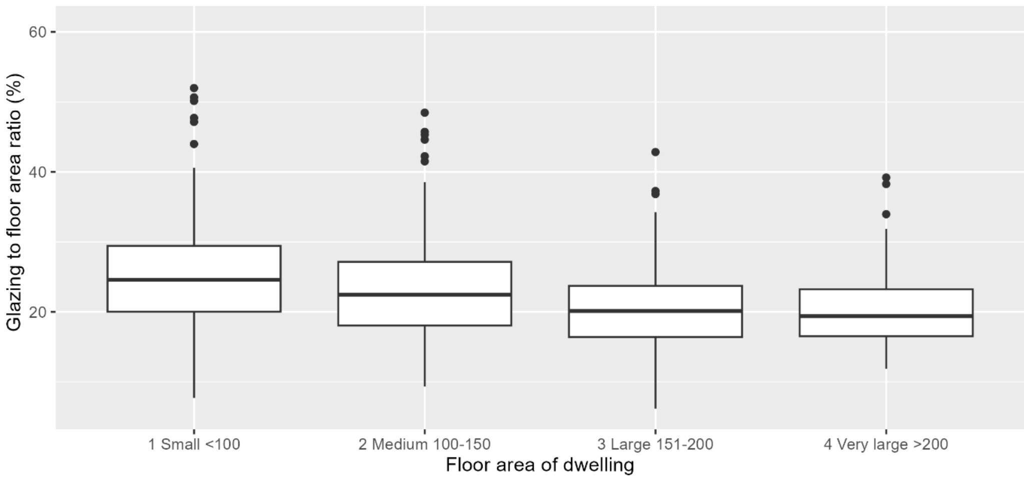


**Figure 11. Distribution of glazing to floor area ratio by grouped dwelling floor area (m²) for HEEP2 sample houses.**

### 2.2.3 Property shade and shelter

The HEEP2 building survey included an assessment of the level of shade and shelter at each dwelling, taking account of the surrounding environment (such as presence of and proximity to other buildings or vegetation). In terms of shelter on the property, half of the sample was considered sheltered (extremely, quite or mildly sheltered) and the other half was considered exposed (semi-exposed or exposed).

About two-thirds (61%) of the houses in the HEEP2 sample were assessed to be shaded at some point in the year, with the remaining 39% estimated to be never or rarely shaded. Neither the level of shelter nor the level of shade was associated with whether the householder felt too warm in summer. However, it is important to note these are relatively crude assessments of site exposure. The shading assessment was intended to focus more on potential for solar gain in winter than the risk of overheating in summer.[5] Future analysis of the data on glazing orientation, eaves and room size should provide a more accurate assessment.

### 2.2.4 Insulation

Research has dispelled the common misconception that insulation causes overheating in homes, especially in summer. Insulation reduces the transfer of heat between the inside and outside of a building, keeping the indoor temperature more stable and comfortable throughout the year (Lomas, 2021; Lomas et al., 2024). In winter, insulation prevents heat loss and keeps the home warmer. In summer, insulation prevents heat gain and keeps the home cooler. Insulation details for the HEEP2 houses are covered in more detail by Anderson et al. (2024).

There was no significant correlation between the householder reporting their home warmer than they would like in summer and the level of roof space insulation in the HEEP2 sample. Future analysis will look in more detail at insulation, actual indoor temperatures (from monitoring data) and other key parameters affecting indoor temperatures in summer.

## 2.3 Section summary

This section of the report provides insights from the HEEP2 householder survey on experiences of comfort in the home in summer and actions taken to help keep cool. This is a subjective assessment of indoor temperatures, providing insight into occupant comfort. The next section of the report looks at preliminary data on actual indoor temperatures recorded by the in-home sensors for a subsample of HEEP2 homes.

[5] For more details on the data collected in the building survey, see the HEEP2 Data Catalogue, available at https://www.branz.co.nz/healthy-homes-research/heep2-energy-use-living-conditions-in-nz-homes/information-for-researchers/.

# 3. Summer 2023/24 subsample – preliminary indoor temperature analysis

This section provides preliminary results of the analysis of indoor temperatures for the Full households that were monitored from December 2023 to February 2024 inclusive. Internal temperatures were monitored in living areas and up to three bedrooms (if present) as well as other spaces where feasible using Tether EnviroQs. The sensors were required to be attached to a wall using 3M Command strips at a height of 1.5 metres above floor level and away from direct sunlight or heat sources.[6] The EnviroQ recorded the rooms' ambient temperature every 15 minutes. Accuracy is specified at ±0.2°C. However, further testing and calibration is being undertaken by BRANZ (see section 3.1.2). Data on external temperatures, sourced from NIWA's CliFlo database[7] for the weather station nearest to each house in the sample, is provided for context.

## 3.1 Summer 2023/24 monitored sample

Of the 425 Full and Medium households that had detailed household and building surveys, 175 of the Full households had in-home temperature data available for the period 1 December 2023 to 29 February 2024.

### 3.1.1 Data processing

Sensors were excluded from analysis if data was not received for the whole period and if less than 95% of the expected data was received. Applying these quality filters reduced the sample size from 175 to 151 houses. While these were spread across New Zealand, as Table 1 shows, there are small numbers of homes in some regions, precluding the reliable presentation of regional level analysis at this stage.

**Table 1. Homes and rooms monitored in HEEP2 Full summer 2023/24 sample.**

| Region | Number of homes | % of homes | Number of bedrooms monitored | Number of living areas monitored |
|---|---|---|---|---|
| Northland | 3 | 2% | 7 | 2 |
| Auckland | 39 | 26% | 78 | 36 |
| Bay of Plenty | 13 | 9% | 34 | 12 |
| Waikato | 11 | 7% | 26 | 11 |
| Hawke's Bay | 5 | 3% | 11 | 4 |
| Taranaki | 6 | 4% | 12 | 3 |
| Manawatū-Whanganui | 19 | 13% | 40 | 19 |
| Wellington | 12 | 8% | 29 | 13 |
| Marlborough | 3 | 2% | 4 | 5 |
| Nelson | 4 | 3% | 6 | 5 |
| Canterbury | 28 | 19% | 49 | 26 |
| Otago | 6 | 4% | 12 | 6 |
| Southland | 2 | 1% | 2 | N/A |
| **Total** | **151** | | **310** | **142**[8] |

[6] The practicalities of real-world fieldwork, house configurations and householder preferences meant this was not always achieved. Data quality checks and reviews of photos of installation placement are being implemented to assess potential impacts on readings.
[7] https://dc.niwa.co.nz/niwa_dc/srv/api/records/66dc62de-dcb3-4dfe-b4d0-06e43dc8a52b
[8] The number of living areas monitored is less than the number of homes in this sample due to sensors in the living room failing/having incomplete data for this period or householders declining having a sensor in the living room.

### 3.1.2 Data health warning and caveats

Other than the checks and exclusions outlined above, no further data checking has yet been undertaken. The data may therefore include periods when houses were empty due to holidays or other absences. In addition, the relatively small HEEP2 summer 2023/24 sample means that unusual temperature patterns in a few households could potentially bias the results. This is especially true where the results are further broken down such as by region or socio-demographic categories. Finally, as noted above, further work is being undertaken by BRANZ to test the temperature sensor response function and address data gaps. Hence, all results here are preliminary only.

### 3.1.3 Summer sample characteristics

Of the 151 households in the summer 2023/24 sample, all but 2 (1%) were owner-occupied, 52% of household respondents were in full-time work, 14% were employed part-time and 34% were not in the labour force. The households were evenly distributed across New Zealand deprivation index quintiles with approximately 20% in each. Their health status was similar to that of the whole sample (14% reported less than good health) and there were similar proportions of respondents who reported their home being always or often warmer than they would like last summer (17%).

Compared to the whole of the HEEP2 Full sample, these homes were less likely to be in Wellington and more likely to be in Manawatū-Whanganui due to the phasing of the HEEP2 fieldwork (Figure 12). They were also less likely to be in the $100,000–150,000 annual household income category. However, statistical analysis suggests that there was no difference on other potentially important dimensions such as respondent age, length of occupancy, dwelling age, dwelling type or floor area.

In all cases, the HEEP2 Full summer 2023/24 results are intended to be illustrative and descriptive as they are based on a partial sample of the complete data that will be available for future analysis. All results should therefore be seen as preliminary and likely to change once analysis of the full data is complete.

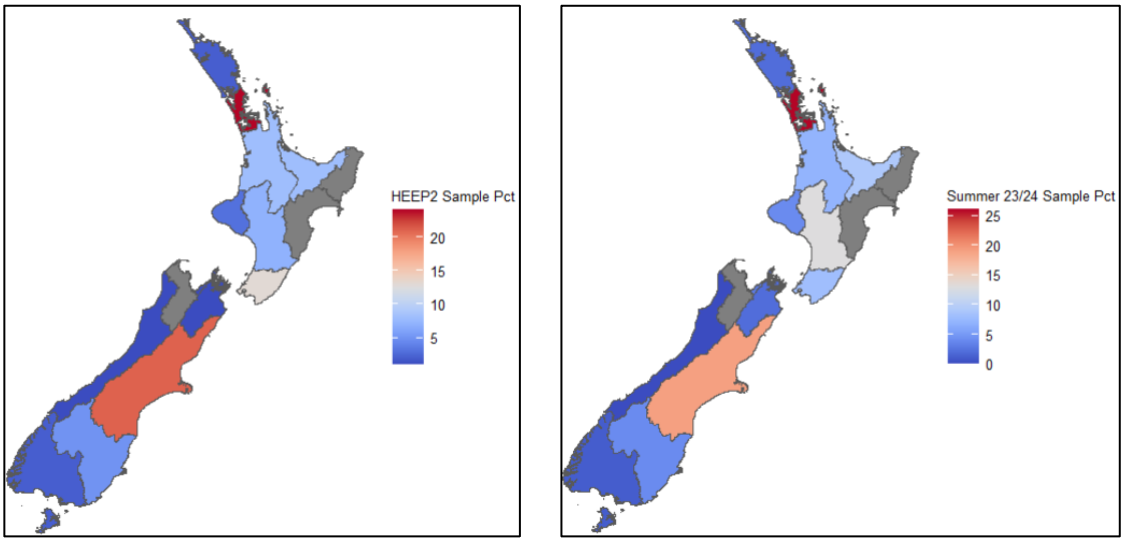


**Figure 12. Relative distribution of the full HEEP2 sample (left) with the summer 2023/24 sample (right) by regional council.**

## 3.2 Seasonal context

According to NIWA, summer 2023/24 was the ninth warmest on record in Aotearoa New Zealand, with temperatures above or well above average throughout the North Island and northern, eastern and inland parts of the South Island (NIWA, 2024).

Overall, the average outdoor temperature was 17.6°C. Of the six main centres, Auckland and Tauranga were equal warmest while Dunedin was the coolest.

Summer 2023/24 was the ninth warmest on record in Aotearoa New Zealand according to NIWA.

In addition, warm and humid conditions were present over much of the country from 19–22 January. This was followed by a period of particularly warm northwest winds across the South Island on 5–6 February with Hanmer Forest in the Canterbury region recording 37°C on 5 February.

The maximum external temperature experienced by the HEEP2 summer 2023/24 sample of houses was 34.7°C in the Canterbury region on 5 February at 17:30 while the minimum was 1.7°C experienced in the Manawatū-Whanganui region at 07:00 on 12 February.

## 3.3 Summer 2023/24 temperatures in HEEP2 living areas and bedrooms

Table 2 shows descriptive statistics for living areas and bedrooms in the HEEP2 summer 2023/24 sample, including the mean and median and 25th and 75th percentile (p25 and p75). The table shows that overall temperatures for bedrooms and living areas are similar at the same times of day. Both rooms were coolest in the mornings (mean 21.1°C) and warmest in the evenings (mean ~24°C) while a quarter (25%) of both living area and bedroom observations were over ~26°C in the evening.

The average temperatures in living rooms and bedrooms are similar across the day, being warmest in the evenings at around 24°C.

**Table 2. Overall descriptive statistics for living areas and bedroom temperatures (°C) in the HEEP2 Full summer 2023/24 sample.**

| Location | Time period | # houses | # rooms | p25 | Median | Mean | p75 |
|---|---|---|---|---|---|---|---|
| Bedroom | Morning 07:00–09:00 | 148 | 310 | 19.6 | 21.2 | 21.10 | 22.7 |
| | Day 09:00–17:00 | 148 | 310 | 21.2 | 23.0 | 22.99 | 24.7 |
| | Evening 17:00–23:00 | 148 | 310 | 22.6 | 24.4 | 24.32 | 26.0 |
| | Night 23:00–07:00 | 148 | 310 | 20.6 | 22.3 | 22.19 | 23.8 |
| Living area | Morning 07:00–09:00 | 135 | 142 | 19.7 | 21.2 | 21.09 | 22.6 |
| | Day 09:00–17:00 | 135 | 142 | 21.5 | 23.2 | 23.20 | 24.9 |
| | Evening 17:00–23:00 | 135 | 142 | 22.9 | 24.4 | 24.41 | 25.9 |
| | Night 23:00–07:00 | 135 | 142 | 20.7 | 22.3 | 22.18 | 23.7 |

Mean temperatures during the night fell by approximately 2°C in both room types, with an overnight mean of ~22°C for both. However, 25% of overnight bedroom observations were over ~24°C at a time when they are most likely to be in use.

To provide further detail on diurnal temperature trends, Figure 13 shows how the median temperature varies across the day for living areas and bedrooms for the HEEP2 summer 2023/24 sample. The ribbon represents the interquartile range (25–75% of observed temperatures) and the plot includes reference lines at 20°C and 25°C as well as the mean external temperature.

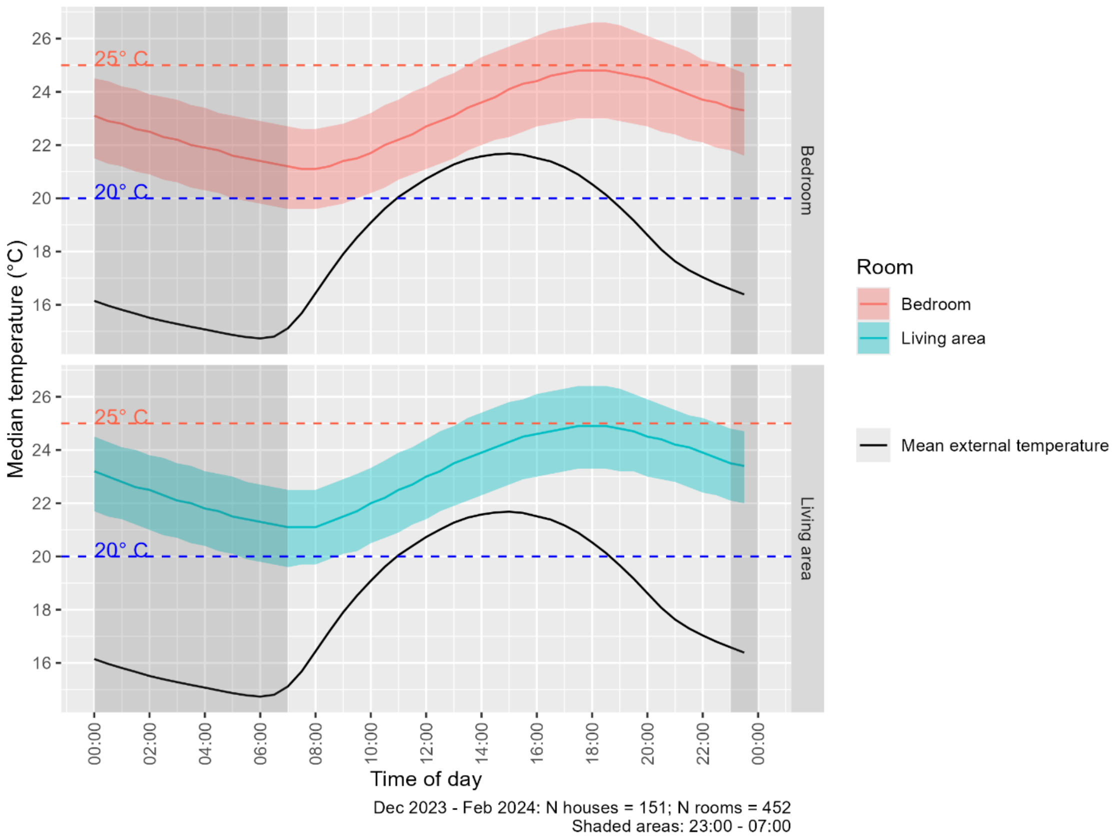


**Figure 13. Half-hourly median and 25/75 temperature percentiles – living areas and bedrooms (HEEP2 summer 2023/24 sample, 20°C and 25°C thresholds and mean external temperature (black) shown for reference).**

As we would expect from the previous results, the general shapes of the curves are similar – with bedrooms showing a slightly larger interquartile range during the day and the houses having a clear mediating effect on overnight low external temperatures.

In terms of comfort, the lag between external and internal temperatures means that almost half of living areas were above 25°C by 18:00, with 25% well over 26°C at a time when they are likely to be occupied. Similarly, 25% of bedrooms were over 24°C at 02:00, and this threshold only declined to 23°C by 07:00.

Preliminary results show a quarter of bedrooms were over 24°C at 2am and around half of living areas were over 25°C at 6pm for the summer 2023/24 sample.

## 3.4 HEEP1 and HEEP2 mean temperatures by room and time of day

The original HEEP1 study collected temperature data for living rooms and bedrooms over the summer period (December to February) between 1999 and 2005 and noted the lack of active cooling with only 4% of homes having air conditioning or a reverse-cycle heat pump at that time (French et al., 2007). In contrast, over 70% of HEEP2 homes have an appliance that could potentially actively cool (see Figure 4), whether or not it is used.

This preliminary comparison of HEEP1 and the HEEP2 summer 2023/24 sample must be treated with caution due to differences in geographical distribution. This is due to phasing of the HEEP2 fieldwork, which meant certain regions are over-represented or under-represented in the summer 2023/24 subset but not in the sample overall. For example, while the proportion of homes in Auckland and Wellington were similar, 8% of HEEP1 homes were in the Northland region compared to just 2% in the HEEP2 summer 2023/24 sample, 2% of HEEP1 homes were in the Taranaki/Manawatū-Whanganui region compared to 17% in the HEEP2 summer 2023/24 sample and only 8% of HEEP1 homes were in the Canterbury region compared to 19% in the HEEP2 summer 2023/24 samples. This analysis will be repeated once the complete set of monitoring data is available.

Noting these potential underlying differences, Table 3 compares summer mean room temperatures and mean external temperatures by times of day for HEEP1 1999–2005 and comparable preliminary HEEP2 results for the summer 2023/24 sample. It shows that mean external temperatures were ~4–8% higher in the HEEP2 sample compared to HEEP1. Mean internal temperatures were also higher and by a slightly larger proportion (6–10%), resulting in a greater difference between the internal-external temperatures for the HEEP2 summer 2023/24 sample (see also Figure 14).

**Table 3. Comparison of preliminary summer mean internal room and external temperatures (°C) by time of day – HEEP1 (1999–2005)[9] vs HEEP2 (summer 2023/24 sample).**

| | Room | HEEP1 (°C) | HEEP2 (°C) | Difference (°C) | Difference (%) | HEEP1 internal-external | HEEP2 internal-external |
|---|---|---|---|---|---|---|---|
| Morning 07:00–09:00 | Living area | 19.2 | 21.1 | 1.9 | 9.9 | 3.4 | 4.7 |
| | Bedroom | 19.1 | 21.1 | 2.0 | 10.5 | 3.3 | 4.7 |
| | External | 15.8 | 16.4 | 0.6 | 3.8 | | |
| Day 09:00–17:00 | Living area | 21.8 | 23.2 | 1.4 | 6.4 | 1.7 | 2.3 |
| | Bedroom | 21.2 | 23.0 | 1.8 | 8.5 | 1.1 | 2.1 |
| | External | 20.1 | 20.9 | 0.8 | 4.0 | | |
| Evening 17:00–23:00 | Living area | 23.1 | 24.4 | 1.3 | 5.6 | 5.2 | 5.2 |
| | Bedroom | 22.6 | 24.3 | 1.7 | 7.5 | 4.7 | 5.1 |
| | External | 17.9 | 19.2 | 1.3 | 7.3 | | |
| Night 23:00–07:00 | Living area | 20.3 | 22.2 | 1.9 | 9.4 | 5.8 | 6.5 |
| | Bedroom | 20.1 | 22.2 | 2.1 | 10.4 | 5.6 | 6.5 |
| | External | 14.5 | 15.7 | 1.2 | 8.3 | | |

[9] French et al., 2007, Table 3.

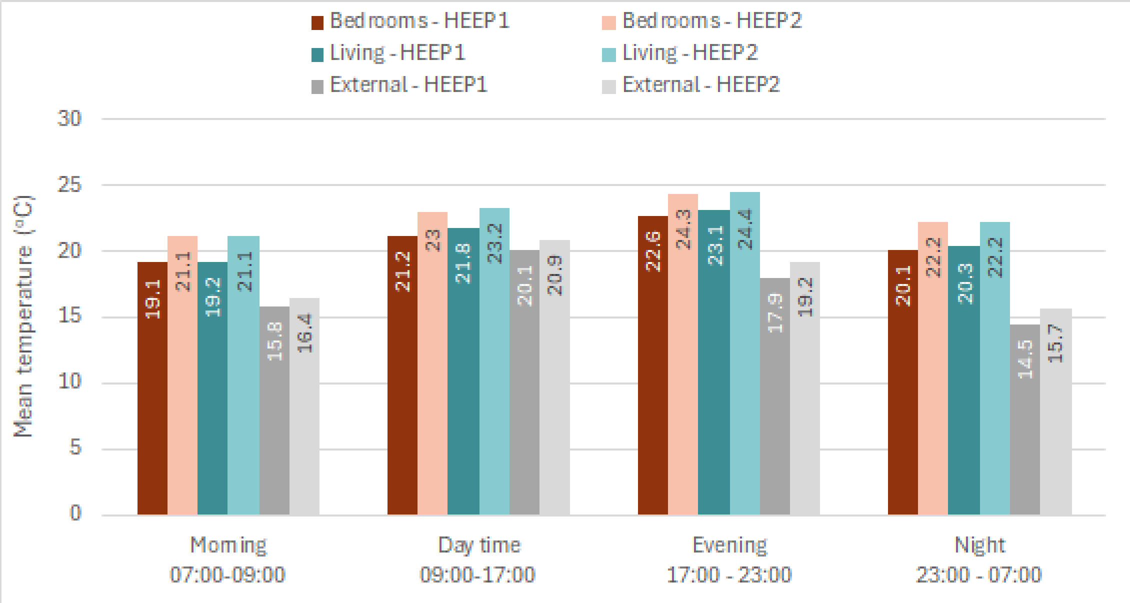


**Figure 14. Mean summer temperatures in bedrooms, living rooms and outside, by time of day for the HEEP1 and HEEP2 2023/24 samples.**

As with the HEEP1 data, there is little difference between mean living area and bedroom temperatures for the HEEP2 summer 2023/24 sample. In addition, as was the case with HEEP1, the moderating effect of the house is also apparent with an internal mean temperature range of 21.1–24.4°C (living areas, HEEP2 summer 2023/24 sample) and 21.1–24.3°C (bedrooms) compared to an external range of 15.7–20.9°C (external, HEEP2 summer 2023/24 sample – see also Figure 13).

A finer-grained comparison can be made using the mean internal temperatures for each room. For example, in HEEP1 the range of mean summer temperatures for both the bedroom and the living room during the morning was approximately 14–24°C (Isaacs et al., 2010, Figure 59). In the case of the HEEP2 summer 2023/24 sample this was 16.6°C to 24.5°C. Thus, while the maximum mean temperatures are broadly similar, the minimum mean morning temperature is higher in HEEP2.

A similar shift is seen for the daytime. In this case, HEEP1 mean temperatures ranged from 16°C to 26°C, while in the case of the HEEP2 summer 2023/24 sample, mean daytime temperatures ranged from approximately 18°C (bedrooms) or 19°C (living areas) to 26°C.

These changes can be seen more clearly by considering temperature thresholds. HEEP1 reporting used a range of 20–25°C to represent comfort temperatures (French et al., 2007), although it is acknowledged that occupants may be comfortable outside of 20–25°C or uncomfortable within this range. Overall, 14% of the HEEP1 homes had mean daytime living room temperatures under 20°C, 85% were between 20°C and 25°C and fewer than 1% were over 25°C. In contrast, 7% of HEEP2 living areas in the summer 2023/24 sample had a mean temperature below 20°C, 82% were 20–25°C and 10% were over 25°C.

This effect is also seen if we consider the number of hours spent within these temperature ranges. Figure 15 shows the distribution of living area daytime hours spent within certain temperature ranges for the HEEP1 and HEEP2 summer 2023/24 sample. HEEP1 results showed that 78% of living areas spent more than half of the daytime period (09:00–17:00) between 20°C and 25°C. In the case of HEEP2, this was 92%. At the cooler end, 13% of HEEP1 living areas spent more than 50% of the daytime period below 20°C. In contrast, this figure was under 2% for the HEEP2 summer 2023/24 sample. At the other end of the comfort continuum, HEEP1 reported 1% of living rooms spent over 50% of the daytime (over 4 hours per day) above 25°C, but for the HEEP2 summer 2023/24 sample, this was over 5%.

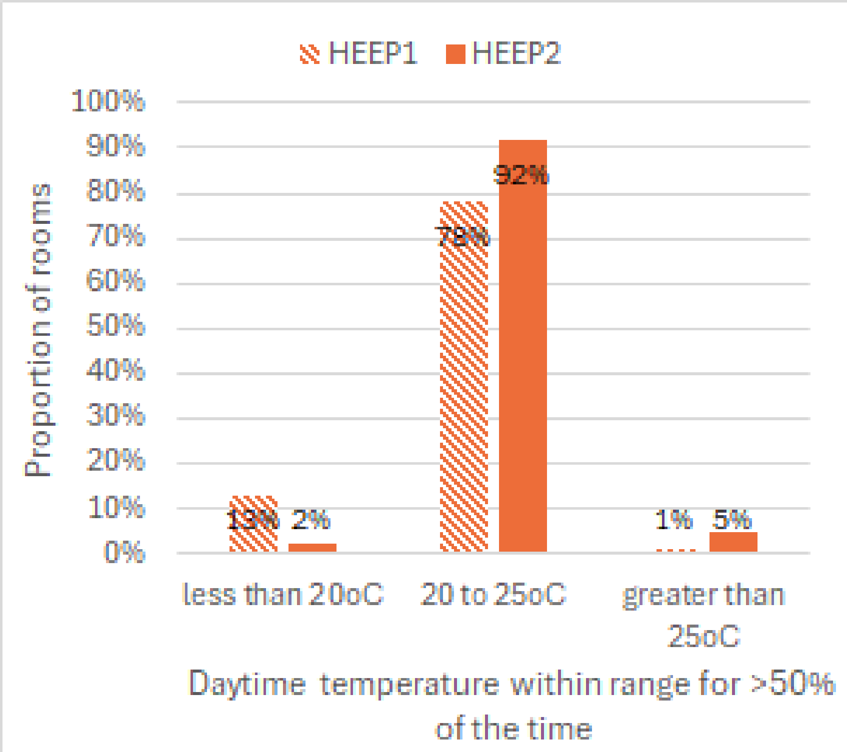


**Figure 15. Percentage of daytime hours spent at given temperature (HEEP1 summer living rooms and HEEP2 Full summer 2023/24 living rooms, daytime hourly means).**

## 3.5 Perceived summer comfort and experienced temperatures

The survey results for the Full and Medium sample showed that around 20% reported that their home was always or often warmer than they would like in summer. This percentage was similar (18%) for the HEEP2 Full summer 2023/24 sample. Figure 16 shows the mean half-hourly temperatures in living areas and bedrooms by how frequently the household respondent said their home was ever warmer than they would like in summer. The plot includes 90% confidence intervals[10] as an indicator of uncertainty.

[10] Calculated using clustered standard errors to allow for the monitoring of multiple living areas or bedrooms within a given home.

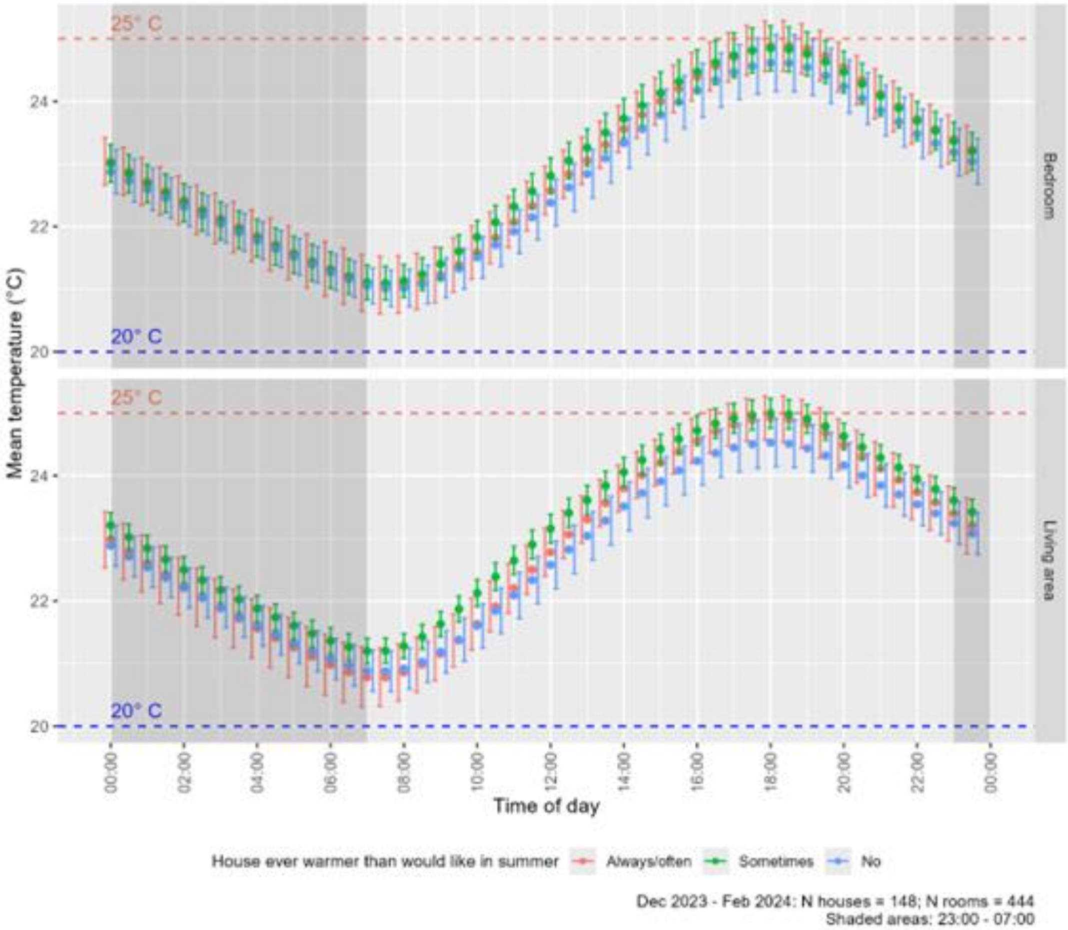


**Figure 16. Mean half-hourly temperature by whether home was warmer than would like in summer – living areas and occupied bedrooms (HEEP2 summer 2023/24 sample, 90% confidence intervals).**

The plot suggests that mean temperatures experienced by the 42 households who said 'no' were slightly lower for living areas during the afternoon and evening. However, there is little apparent difference in the mean half-hourly observed indoor temperature between those who reported their home being 'always/often' (n=26 households) or 'sometimes' (n=80) warmer than they would like.

The lack of a clear distinction in experienced mean half-hourly temperatures between the self-reported comfort categories should not be surprising. For example, the whole-summer mean half-hourly temperatures will mask specific warmer days to which those who responded 'sometimes' might be referring. More importantly, the subjective nature of comfort means that some occupants are likely to report that their home was always warmer than they would like at temperatures others would consider mostly comfortable and vice versa. Further, it is well known that there are a range of cues and elements beyond experienced climatic variables that contribute to subjective descriptions of comfort (Molina et al., 2023).

## 3.6 Regional differences

Figure 17 and Figure 18 show the distribution of mean temperatures by room, time of day and region – where there were more than 10 homes in the HEEP2 Full summer 2023/24 sample.

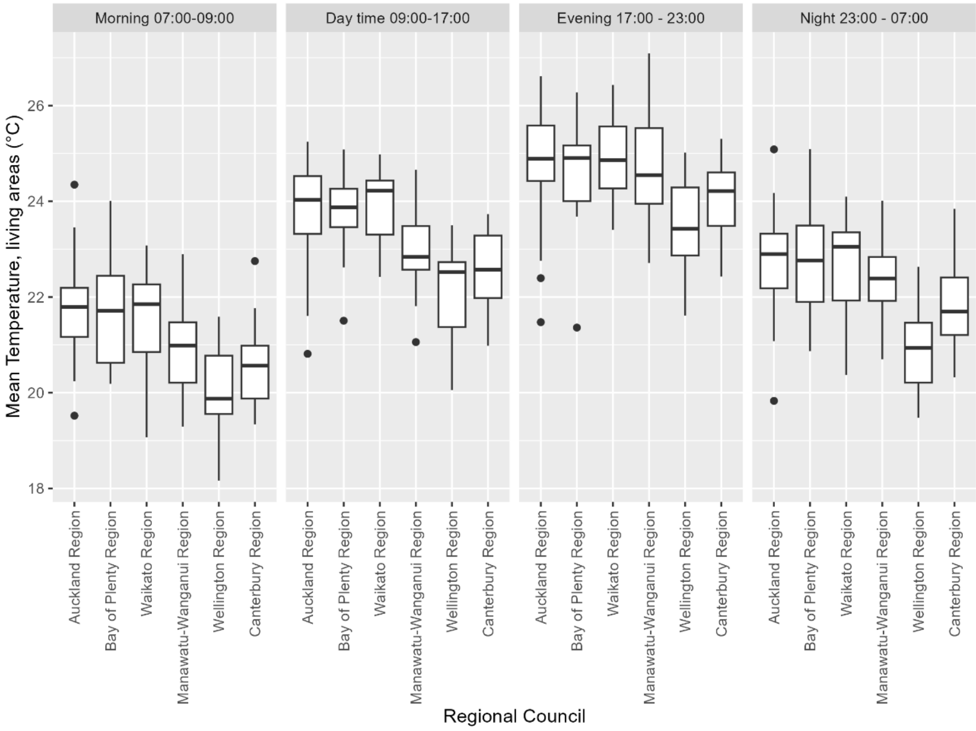


**Figure 17. Distribution of mean temperatures in living areas by time of day and region (HEEP2 summer 2023/24 sample).**

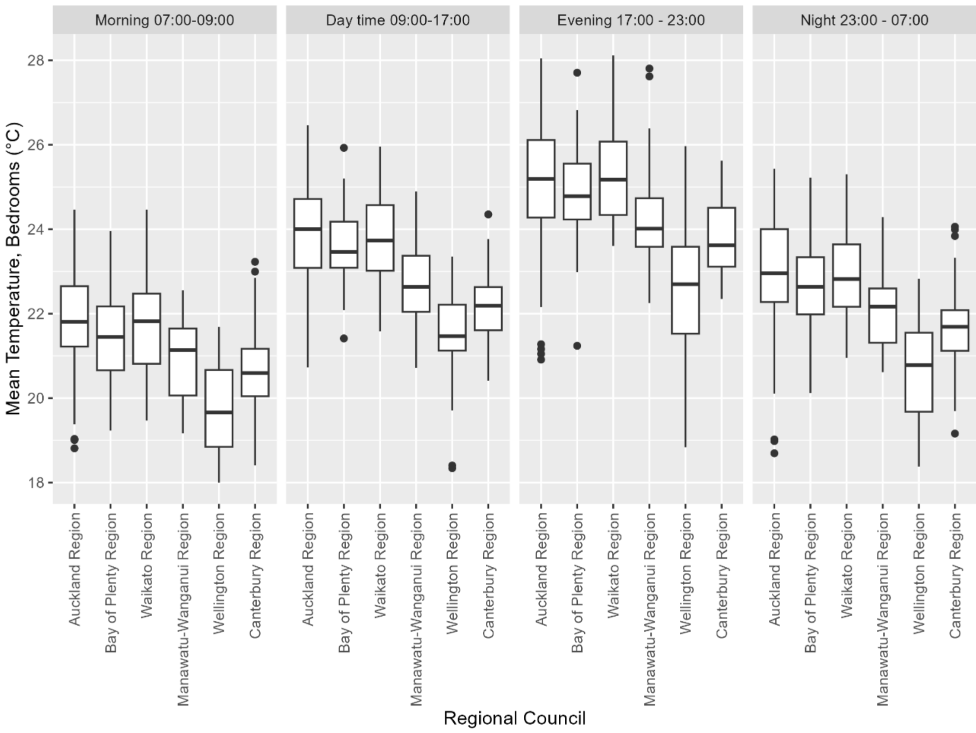


**Figure 18. Distribution of mean temperatures in bedrooms by time of day and regional (HEEP2 summer 2023/24 sample).**

Given the small numbers of homes in some of these areas (see Table 1), these results should be viewed with caution. Nevertheless, they show the expected regional trend with more northerly regions generally warmer than the more southerly, although rooms in Canterbury are notably warmer than those in Wellington.

As observed in HEEP1 and noted above, there will be a number of factors beyond geographical location affecting indoor temperatures such as regional geography (impact of hills on solar gain/shading) and variations in housing typology, including age, and key design elements like window sizes and orientation (Isaacs et al., 2010). These will be explored in future analyses with the complete set of HEEP2 data.

## 3.7 Overheating in bedrooms

This section assesses the incidence of overheating in bedrooms in the HEEP2 Full summer 2023/24 sample using the fixed threshold CIBSE 1b criteria for predominantly naturally ventilated homes. This criteria states that the temperature in a bedroom from 22:00 to 07:00 should not exceed 26°C for more than 1% of annual hours (CIBSE, 2017). The criteria also note that 1% of the annual hours between 22:00 and 07:00 is 32 hours, thus 33 or more hours above 26°C will be recorded as overheating.

Applying the CIBSE 1b criteria shows that, of the 310 bedrooms monitored in this sample, 111 (36%) had temperatures of over 26°C for more than 33 hours in the 22:00–07:00 period.

As we would expect given the regional results reported above, overheating rates varied by region with 45 (58%) of the 78 monitored Auckland bedrooms failing the criteria, but this was the case for only 1 (3%) of the 29 monitored Wellington bedrooms (Table 4).

**Table 4. CIBSE 1b overheating rates for regions with more than 20 monitored bedrooms.**

| Region | # bedrooms | % failed |
|---|---|---|
| Auckland | 78 | 58% |
| Bay of Plenty | 34 | 44% |
| Waikato | 26 | 46% |
| Manawatū-Whanganui | 40 | 28% |
| Wellington | 29 | 3% |
| Canterbury | 49 | 22% |

Perhaps unsurprisingly given the results reported in section 3.5, bedrooms where the respondent said their home was 'always/often' or 'not' warmer than they would like in summer had similar rates of overheating (33% and 34% respectively). Those who said their home was sometimes warmer than they would like had a slightly higher overheating rate (38%).

Future work with the complete sample will extend this analysis to include living rooms, using additional CIBSE overheating criteria, and will seek to understand in more detail the factors that are associated with overheating across both room types.

# 4. Summary and future work

This report presents preliminary analysis of summer comfort and cooling-related survey data for the (unweighted) HEEP2 Full and Medium samples together with preliminary analysis of living area and bedroom temperature data for a subsample of homes monitored over summer 2023/24.

The survey analysis shows that around 70% of the 425 survey respondents reported that their home was warmer than they'd like at least some of the time in summer. For around 1 in 5 (22%), this was always or often warmer than they'd like. These proportions are higher than those stating their home was colder than they would like in winter (14% always or often, 48% at least some of the time).[11]

Respondents who said their home was always/often warmer than they would like in the HEEP2 sample were more likely to be younger, live in joined homes and live in smaller homes. However, there was little difference in occupant-reported summer comfort by income, glazing to floor area ratio, roof insulation levels or experienced temperatures for this sample. Intriguingly, 29% of Wellingtonians surveyed said they were always/often warmer compared to 24% of Aucklanders, even though the indoor temperatures Wellingtonians experienced were lower and far fewer of their bedrooms were classed as overheating. There will be a wide range of factors underlying subjective comfort observations, including dwelling characteristics, householder preferences, daily habits and routines and the householder's ability to cool the home.

The survey data showed that 72% of the HEEP2 respondents with a heat pump or air conditioning reported using it to actively cool their living room at least some time in summer (equivalent to 52% of all surveyed households), while 18% did this every day or most days in summer (13% of all surveyed households). This finding is comparable to other recent studies (O'Sullivan, 2024) but is substantially higher than that reported in the BRANZ heat pump study (Burrough et al., 2015), which predicted that heat pumps would lead to an increase in summer electricity cooling load.

Bedroom cooling on the other hand was less frequent. Only 13% of those with a heat pump or air conditioning in the bedroom reported doing so every day or most days. This was equivalent to just 3% of all homes surveyed due to fewer heat pumps in bedrooms. As we might expect, those who never felt their house was too warm in summer hardly ever or never used active cooling in the main living area. There is some evidence that older and lower-income groups in the HEEP2 sample are more likely to report never using active cooling.

Other ways to cool that were commonly mentioned were opening doors and windows to get a cross-breeze and leaving windows open all day (~80%). Closing curtains and blinds and leaving windows open at night or using electric fans (~50%) was also common, but fewer (<20%) reported using their heat pump or AC on a purely fan setting. The use of awnings and louvres for shade was rarer still (10%).

Preliminary analysis of the 151 houses for which there was sufficient quality temperature data for December 2023 to February 2024 showed that both bedroom and living area median temperatures peaked at around 25°C at approximately 6pm, some 3 hours after the peak mean external temperature. Median internal temperatures then fell to around 21°C by 7am. A quarter of living area observations were over 26°C at

[11] This includes those who said their home was warmer/colder than they'd like always, often or sometimes.

6pm. Similarly, 25% of bedroom observations were over 24°C at 2am. Unlike the observations from the first HEEP2 winter analysis (Anderson et al., 2024), there was little difference in temperatures between living areas and bedrooms.

Noting there are some differences between the two HEEP study samples, preliminary results comparing the HEEP2 summer 2023/24 sample to the original HEEP1 study (1999-2005) suggest mean temperatures in both living areas and bedrooms have increased over the last 20 years by between 1.3°C (living areas in the evening) and 2.1°C (bedrooms overnight). These early findings also suggest that more living areas were warmer for longer during the day in the HEEP2 summer 2023/24 sample than HEEP1. HEEP1 found that 1% of living rooms experienced more than 50% of hours over 25°C but this was over 5% for the HEEP2 summer 2023/24 sample. The latter also found 10% had a mean daytime temperature over 25°C compared to just 1% in HEEP1.

Regional variation in internal temperatures for this sample follows expected patterns with both bedrooms and living rooms in Auckland tending to be warmer than other regions with sufficient sample sizes for comparison.

Preliminary analysis of overheating in bedrooms using the industry standard CIBSE 1b criteria showed that 36% of the 310 monitored bedrooms were classed as overheating. In line with the regional variation described above, this rose to 58% of the 45 Auckland bedrooms but was only 3% (1) of the 29 Wellington bedrooms monitored. However, there was no clear difference in overheating rates for those who reported their home as always/often too warm vs never too warm.

These results are intended to provide illustrative and preliminary analysis of a subset of the data being collected by the HEEP2 study. The survey results presented give an indication of the household socio-economic statuses and some of the dwelling and room-level data that will be linked to the internal temperature and other monitored data in future analyses. The survey data provides context and valuable insights. Preliminary analysis of internal temperatures for the partial HEEP2 Full summer 2023/24 sample showed expected change since HEEP1 and expected differences across regions. However, substantial further work is needed to assess the relative importance of other factors. BRANZ research has shown that, when designing for energy efficiency and comfort (including avoiding overheating during warmer weather), homes should be considered as a system and not a set of individual components. A number of factors, including orientation of the building site, the number and position of windows, shading, insulation, heating and cooling systems and ventilation, work together to govern how comfortable people will be in their homes at different times of the year (BRANZ, 2025). Future work with the complete HEEP2 dataset will extend the analysis presented here to provide a more detailed exploration of the factors affecting indoor summer temperatures and the risk of overheating.

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