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Residential Firewood Consumption in Australia

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Executive summary

Australian households use a range of energy sources to power their everyday lives. While many consumers rely on electricity, gas and solar, some also use firewood as a fuel source. Yet there is little up-to-date data available on residential firewood consumption in Australia. For the Australian Government, this presents challenges for devising accurate estimates of firewood consumption for publications such as the Australian Energy Statistics (AES). In the past, estimates of residential firewood consumption have been based on information such as the number of households and number of wood heaters per state. However, there is scope to improve the accuracy and robustness of these estimates by using more recent data and applying a new analytical methodology that considers a larger number of variables.

In FY 2018-19, the CSIRO aimed to improve past estimates of residential firewood consumption by conducting a survey of Australian households using the CSIRO Energise mobile app. The self-report data collected through this survey was used to generate estimates of firewood consumption per state/territory based on location and dwelling type. Due to the preliminary nature of this research, however, further work is needed to validate the initial estimates using a larger and more representative sample of consumers. There is also value in repeated surveying of households (i.e. longitudinal data collection) in order to explore changes in firewood consumption over time.

To this end, the current research builds on CSIRO's earlier work with a view to improving the accuracy of residential firewood consumption estimates for the Australian Energy Statistics. In 2019, two new surveys were conducted – one using the CSIRO Energise app (n = 770 households) and another using an online research panel (n = 4,074) – in order to collect self-report information on firewood consumption from a larger, more geographically representative sample of Australian households. The survey included general questions about demographics, household characteristics and dwelling factors, as well as more specific questions about the ownership and use of wood-fired appliances for domestic purposes such as heating, cooking and hot water. Importantly, the survey also asked respondents to provide an overall estimate of the total amount of firewood used by their household in the past year, which served as the key outcome variable of interest.

The survey results revealed that the proportion of firewood users varies significantly due to factors such as geographical location and household demographics. Overall, approximately one-quarter of the sample (24%) reported using firewood as an energy source at home; however, the proportion of firewood users varied across states and territories. For example, rates of firewood consumption were higher among those living in Tasmania (38%), Victoria (28%), Western Australia (27%), South Australia (25%) and lower among those living in New South Wales (23%), Northern Territory (22%), the Australian Capital Territory (18%) and Queensland (17%). More in-depth analyses revealed that geographical location not only predicts the proportion of households that use wood as an energy source, but also the timing and frequency of firewood use, whether wood is used for indoor space heating, and whether wood is a household's main source of indoor space heating. Overall, these factors play a key role in explaining variability in the amount of firewood consumed by individual households, as well as the amount consumed per state and territory.

Alongside examining the key predictors of residential firewood use in Australia, analyses were also conducted to produce up-to-date estimates of residential firewood consumption for each state and territory. Nationwide, it was estimated that Australian households consume between 4.1 and 4.2 million tonnes of firewood per year, which equates to between 67.6 and 69.4 petajoules. Due to differences in population sizes and climatic conditions, however, there was considerable variability across different parts of the country. For example, total firewood consumption (i.e. tonnes per state/territory) was estimated to be highest for Victoria and New South Wales, but lowest for the Northern Territory and the Australian Capital Territory. When considering firewood use on a per household basis, however, results revealed above-average wood consumption (i.e. tonnes per household) for those living in Tasmania, Victoria and South Australia, but below-average wood consumption for those living in Western Australia, New South Wales, the Australian Capital Territory, the Northern Territory and Queensland.

These estimates of firewood consumption can be compared to past research and official published statistics; however, it is important to note that different studies have used different data sources, research methods, analytical approaches and samples – all of which may influence the results. The current research also has some limitations that are worth highlighting. For instance, the estimates of firewood consumption are based solely on self-report survey data, which is inherently subject to some degree of error. The sample of households taking part in this research were also not fully representative of the broader population across all demographic and dwelling characteristics of interest. While efforts were made to recruit a large sample that included a good mix of different household types, there was still some degree of sampling bias in the types of people who were surveyed. Finally, the current research was cross-sectional in nature, with data collected at one period in time. Although steps have been taken to compare results with an earlier 2018 survey, the data collected and subjected to analysis only spans a short timeframe (i.e. one to two years). In turn, while efforts have been made to start exploring temporal variability in firewood use, further research over a longer timeframe is needed to draw stronger conclusions about changes in residential firewood consumption over time. This would be a fruitful avenue for future research.

1 Introduction

Australian households use a range of energy sources to power their everyday lives. While many residential consumers rely on electricity, gas and solar, some households also use firewood as a fuel source. Yet there is limited up-to-date information available on exactly *how much* firewood is consumed by households across the country. This lack of data is partly due to various challenges with estimating firewood consumption in the residential sector, including difficulties in obtaining objective information on firewood use and the lack of an accurate, universally-understood unit of measurement. Firewood can also be sourced in different ways (e.g. self-collection, purchases, or receiving for free) and used for various purposes (e.g. heating, cooking, hot water), making it hard for households to accurately report their firewood consumption when asked.

Internationally, researchers have typically used surveys or interviews to gather data on household firewood consumption (for examples, see Arabatzis & Malesios, 2011; Couture et al., 2012; Glasenapp et al., 2019; Hardie & Hassan, 1986; Lillemo & Halvorsen, 2013; Lindroos, 2011; Marsinko et al., 1984; Song et al., 2012), with similar data collection methods used in Australia. However, the most recent national survey on firewood use (see Driscoll et al., 2000) is almost two decades old, which raises questions over the validity and generalisability of previous results to the present day. Indeed, some research suggests that firewood consumption has been decreasing significantly over the years in Australia, with this pattern expected to continue in the future as traditional wood heating is replaced with electric and gas heating (Firoz et al., 2008). However, further research – underpinned by empirical evidence – is needed to fully understand the nature and rate of this change over time.

Currently, the lack of robust and reliable data on household firewood use poses a challenge for the Australian Government, which is responsible for publishing estimates of residential firewood consumption as part of the Australian Energy Statistics (AES). Updated annually, the AES serves as the nation's authoritative and official source of energy statistics. It forms the basis of Australia's international reporting obligations and includes historical energy consumption, production and trade statistics. In turn, it is critically important that the estimates of residential firewood consumption published as part of the AES are statistically sound, accurate and up-to-date.

1.1 Previous estimates of residential firewood consumption

Historically, estimates of residential firewood consumption in Australia have been based on limited and/or outdated information. The most recent report by Driscoll et al. (2000) estimated that Australian households consume between 4.5 and 5.5 million tonnes of firewood per annum, with more than half of this amount consumed in New South Wales and Victoria alone. Based on survey data from almost 2,200 respondents, including 418 firewood users (19% of the total sample), this study found that firewood consumption varied nationally. The average firewood-using household was estimated to burn 3 tonnes of firewood each year; however, this ranged from a low of 1.3 tonnes per year in Queensland through to a high of 5.8 tonnes per year in Tasmania. According to Driscoll et al. (2000), households in capital cities consumed significantly

less firewood compared to those in the rest of each state/territory (average of 2.2 vs. 3.7 tonnes per household per year).

Since this study was published almost two decades ago, few efforts have been made to collect new primary data on residential firewood consumption in Australia. This lack of up-to-date data has made it difficult for the Australian Government to provide accurate estimates of firewood use as part of its annual reporting of energy statistics. For the 2018 AES, for example, wood consumption was estimated using a simple Ordinary Least Squares regression against the number of households per state (based on Australian Demographic Statistics) and the number of wood heaters per state (based on the Department's 2015 Residential Energy Baseline Study). However, there is scope to improve the accuracy of these estimates by using more recent data and applying a new statistical method that considers a larger number of variables that predict usage of wood-fired appliances.

In 2018, the CSIRO aimed to improve past estimates of residential firewood consumption by collecting new data through the CSIRO Energise mobile app, a smart device application that allowed Australian adults aged 18+ years old to complete short surveys over time. Nationwide, a total of 1,560 people answered a range of questions about their use of wood-fired appliances at home. Overall, one-in-four survey respondents (25%) reported using wood as an energy source – primarily for space heating (84% of wood-burning households), as well as other domestic activities such as running cooktops and ovens (7% of wood-burning households), outdoor barbeques and pizza ovens (23% of wood-burning households), and even hot water systems (2% of wood-burning households).

In order to measure levels of firewood consumption across the Australian population, the 2018 CSIRO Energise survey asked these so-called 'firewood users' to estimate the total amount of firewood consumed by their household in the past 12 months. Approximately 300 respondents answered this question, with CSIRO researchers then using this self-report survey data to generate new estimates for the total amount of firewood consumed in each Australian state and territory. Due to the survey's relatively small and self-selected sample of respondents, however, it was concluded that further research was needed to replicate and validate the initial estimate of firewood consumption using a larger and more representative sample of Australian households.

1.2 The current research

The current research extends on CSIRO's previous work in 2018 with a view to improving the estimates of residential firewood consumption for the Australian Government's 2020 AES. To this end, two new surveys have been conducted in order to collect data on firewood use from a larger and more geographically representative sample of Australian households. In the sections that follow, this survey methodology is described in more detail, followed by an overview of the survey sample's characteristics and the statistical approach used to analyse the data that was collected. Results are subsequently presented, first in terms of descriptive statistics (e.g. frequencies and percentages) for individual survey questions, second in terms of the key predictors of firewood use, and third in terms of overall estimates of firewood consumption per state and territory. Finally, a preliminary analysis of longitudinal (i.e. repeated measures) data is also presented in order to explore changes in self-reported firewood consumption patterns over time. We conclude with a brief discussion of key results, limitations, and implications for future research in this area.

2 Methodology

2.1 Research design and procedure

Building on the CSIRO's earlier research from 2018, which involved conducting an initial firewood survey via the CSIRO Energise app, two new surveys were conducted in 2019 to collect more up-to-date data on residential firewood consumption across Australia.

Table 1 below summarises the key features of each survey. More specifically:

1) In August 2019, a dedicated firewood survey was conducted via the CSIRO Energise app. Alongside the primary objective of gathering more up-to-date information on firewood consumption, this survey aimed to collect longitudinal data (i.e. repeated surveying of the same households over time) in order to explore temporal changes in firewood use. Overall, a total of 770 people across Australia took part in the survey between 1 August and 15 October 2019, with the majority (87%) completing the survey during winter.

2) In September 2019, an online panel provider (I-view Pty Ltd) was engaged to conduct a second survey of a larger and more representative sample of Australian households[1]. To allow robust and reliable estimates of firewood consumption to be calculated for each state and territory, the survey was purposely designed to target around 950 firewood users nationwide[2]. Based on CSIRO's past research, it was predicted that about one-quarter of all households would use wood as an energy source, and in turn, approximately 4,000 panel members would need to be surveyed in order to achieve the target number of firewood users. Overall, a total of 4,074 people across Australia completed the online panel survey between 26 September and 6 October 2019.

Appendices 9.1 and 9.2 present the full set of questions for the CSIRO Energise firewood survey and online panel survey, respectively. In both cases, the question content was very similar to that of the 2018 CSIRO Energise firewood survey (see Appendix 9.3). Respondents were asked a range of questions about the ownership and use of wood-fired appliances for domestic purposes, such as space heating (e.g. fireplaces), cooking (e.g. wood-burning ovens, stoves, cooktops, barbeques) and hot water (e.g. wood-fired water heaters). The online panel survey also collected some basic information on the demographic, household and dwelling characteristics of respondents. This extra information was not embedded in the CSIRO Energise survey, however, as such details had been already been collected through earlier (non-firewood) CSIRO Energise surveys.

[1] While the use of an online panel provider allowed a larger and more representative sample of Australian households to be recruited compared to the CSIRO Energise app, this approach still has some limitations that are worth noting. For example, although online panel providers typically have information about the background characteristics of panellists and this can be used to obtain a sample that is representative across certain socio-demographics (e.g. state/territory of residence, age/gender of respondent, etc.), the sample nevertheless remains restricted to those people who sign up to online panels. Panellists may not be truly representative of the broader Australian population across other key characteristics of interest. For example, they may have different attitudes, interests, values and beliefs to that of the general population. Despite this drawback, the use of online panel providers often remains the most efficient and cost-effective way of reaching a large sample of participants for survey-based research.

[2] Approximately 150 firewood users were targeted per state/territory; however, due to smaller numbers of panel participants in some geographical areas, lower sample size targets were set for Tasmania (n=110), the Australian Capital Territory (n=70), and the Northern Territory (n=20).

Table 1. Summary of CSIRO's two surveys in 2019 to collect new primary data on firewood consumption

	1. CSIRO Energise Survey	2. Online Panel Survey
Participant sample	Australians who have registered as users of the CSIRO Energise app	Australians who have registered to participate in paid online surveys
Targets	None	Targets were set for the minimum number of firewood users to survey per state/territory: NSW, VIC, QLD, SA and WA: n=150 firewood users per state (sub-total n=750 across five states); TAS: n=110; NT: n=20; ACT: n=70
Final sample size	770 respondents nationwide, with 210 respondents (27.3%) using firewood at home	4,074 respondents nationwide, with 958 respondents (23.5%) using firewood at home
Data collection time-frame	August to October 2019	September to October 2019
Survey content	Various questions about the ownership and use of wood-fired appliances, as well as total firewood consumption over the preceding 12 months. Data on basic demographic, household and dwelling characteristics was sourced from other CSIRO Energise surveys.	Various questions about the ownership and use of wood-fired appliances, as well as total firewood consumption over the preceding 12 months. Questions about standard demographic, household and dwelling characteristics were also asked.

2.2 Sample representativeness

In this section, we briefly summarise the representativeness of our survey respondents across key demographic and dwelling characteristics, including location (based on residential postcode), age (based on year of birth), dwelling type, housing tenure, household size and composition, and total household income per annum. Summary results are presented for each survey separately (i.e. 'CSIRO Energise' and 'Online panel') as well as together (i.e. 'Combined sample'). To evaluate the degree to which our sample of survey respondents aligns with the broader Australian population across these demographic and dwelling characteristics, comparisons are made with data from the Australian Bureau of Statistics' (ABS) 2016 Census of Population and Housing[3].

Geographical location

Self-report data on the residential postcode of survey respondents was used to determine their state/territory of residence. As shown in Table 2, the proportion of respondents per state/territory varied across the two surveys. This finding is not unexpected, however, as location-based targets (based on postcode) were applied when recruiting participants for the online panel survey, but not the CSIRO Energise survey. To explain further, one goal of this research was to maximise the number of firewood users that were surveyed per state/territory. For the online panel survey, it was possible to set targets based on the geographical location of respondents to ensure that a pre-defined minimum number of firewood users were surveyed in each state/territory. However, this use of location-based targets was not possible for the CSIRO Energise survey. As a result, some

[3] ABS Census data was sourced using the ABS TableBuilder tool, see: https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder

differences emerged between the two survey samples in the geographical composition and representativeness (or lack thereof) of respondents.

Table 2. Distribution of the survey samples across Australian states and territories

STATE/TERRITORY OF RESIDENCE	CSIRO ENERGISE		ONLINE PANEL		TOTAL SAMPLE	
	N	%	N	%	N	%
Australian Capital Territory	41	5.3%	372	9.1%	413	8.5%
New South Wales	244	31.7%	705	17.3%	949	19.6%
Northern Territory	9	1.2%	97	2.4%	106	2.2%
Queensland	105	13.6%	885	21.7%	990	20.4%
South Australia	73	9.5%	585	14.4%	658	13.6%
Tasmania	32	4.2%	298	7.3%	330	6.8%
Victoria	190	24.7%	590	14.5%	780	16.1%
Western Australia	61	7.9%	532	13.1%	593	12.2%
Not defined	15	1.9%	10	0.2%	25	0.5%
Total	770	100%	4074	100%	4844	100%

Note: State/territory of residence was based on the self-reported postcode of survey respondents. A small number of postcodes cover more than one state or territory. As postcode was the only measure of geographical location captured in the survey, ABS correspondence files were used to categorise these postcodes into one state or territory only. For example, respondents who reported living in postcode 2620 could be living in either ACT or NSW, but for the purpose of this research have been categorised as ACT. On the other hand, respondents living in postcodes 2611 and 2619 have been categorised as NSW.

As shown in Figure 1, the geographical composition of the CSIRO Energise survey sample was more aligned with the ABS 2016 Census than that of the online panel survey sample. For example, the CSIRO Energise sample had a higher proportion of survey respondents living in New South Wales and Victoria (the two most populated states in Australia), but a lower proportion of respondents living in the Australian Capital Territory, the Northern Territory, Tasmania and Western Australia. In contrast, the online panel survey was purposely designed to sample a specific number of firewood users per state and territory (refer to the targets in Table 1). This ultimately meant that we sampled a higher proportion of the overall population in those states/territories with fewer households (e.g. the Northern Territory, the Australian Capital Territory, Tasmania and South Australia), and conversely a lower proportion of the overall population in those states/territories with more households (e.g. Western Australia, Queensland, Victoria and New South Wales). In turn, the geographical composition of the online panel survey sample (in terms of the proportion of respondents per state/territory) differed from that of the CSIRO Energise survey.

In terms of the overall (i.e. combined) sample, Figure 1 shows that when compared with data from the ABS 2016 Census, the combined sample of survey respondents was not fully representative of the broader Australian population in terms of geographical location. However, as explained above, this finding is expected given that the online panel survey imposed location-based targets, thereby effectively over-sampling some geographical areas but under-sampling others.

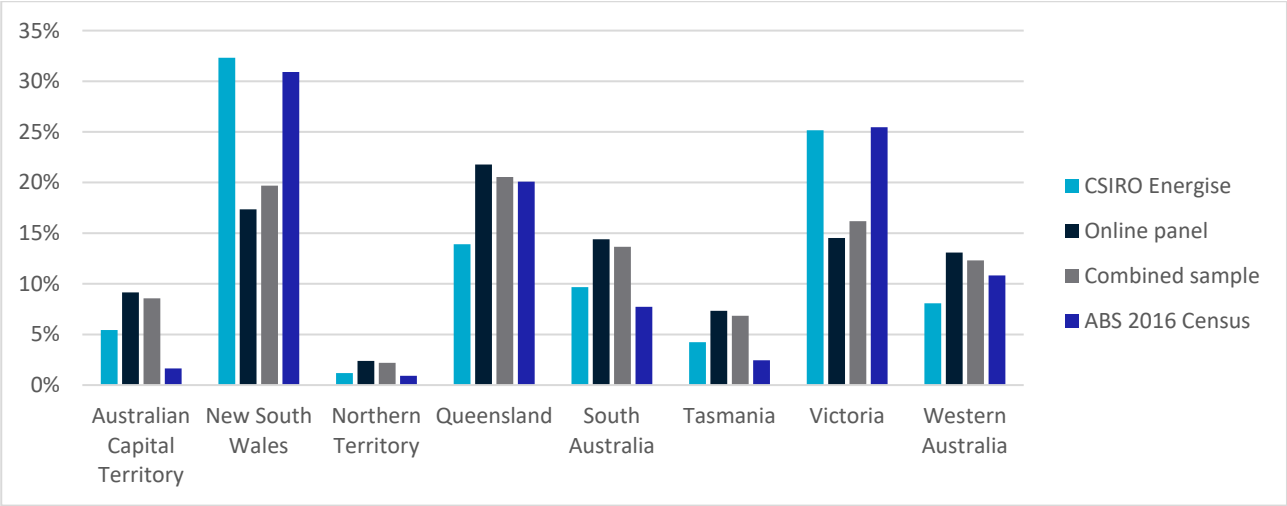


Figure 1. Sample representativeness: geographical location of survey respondents (n=4,819)[4] compared with the broader Australian population (based on ABS 2016 Census data)

Respondents' age (based on year of birth)

As shown in Figure 2, compared with the broader Australian population based on ABS 2016 Census data, the combined survey sample was under-represented by respondents aged between 18 and 29 years old, but over-represented by respondents aged 60 years old and above.

In addition, when comparing the two survey samples separately, it appears that the proportion of respondents within each age category varied between recruitment modes, especially among the younger (18 to 29 years old) and older (70 years old and above) age categories. For example, the CSIRO Energise sample had a lower proportion of respondents aged between 18 and 29 years old (2%) compared to the online panel sample (9%) and the ABS 2016 Census (21%). On the other hand, the online panel sample had a higher proportion of respondents aged 70 years old and above (26%) compared to the CSIRO Energise sample (16%) and the ABS 2016 Census (14%).

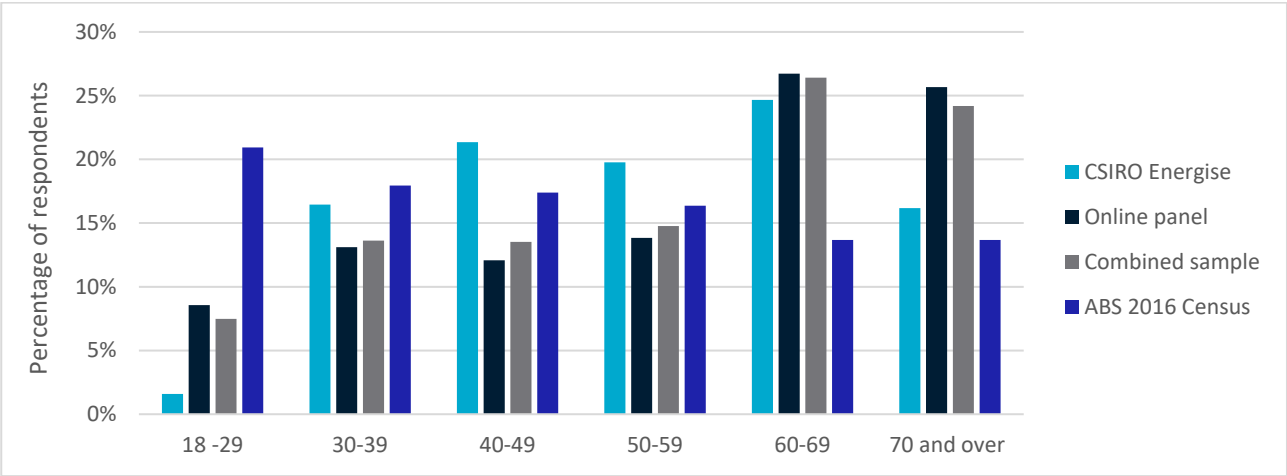


Figure 2. Sample representativeness: age of survey respondents (n=4,828)[5] compared with the broader Australian population (based on ABS 2016 Census data)

[4] Excludes 25 respondents who did not provide a valid postcode.

[5] Excludes 16 respondents who did not state year of birth.

Dwelling type

As shown in Figure 3, the combined survey sample had a slightly higher proportion of respondents living in separate houses (76%) and slightly lower proportion living in semi-detached dwellings (9%) compared with the broader Australian population based on ABS 2016 Census data (71% and 13%, respectively). However, the proportion of survey respondents who reported living in flats, units or apartments was relatively similar to that of the broader Australian population (14% each).

In addition, when comparing the two survey samples separately, it appears that the proportion of respondents within each dwelling type category varied slightly between recruitment modes. For example, the proportion of respondents living in separate dwellings or flats/units/apartments in the online panel sample (75% and 14%, respectively) was more aligned with the ABS 2016 Census (71% and 14%, respectively) than the CSIRO Energise sample (78% and 11%, respectively).

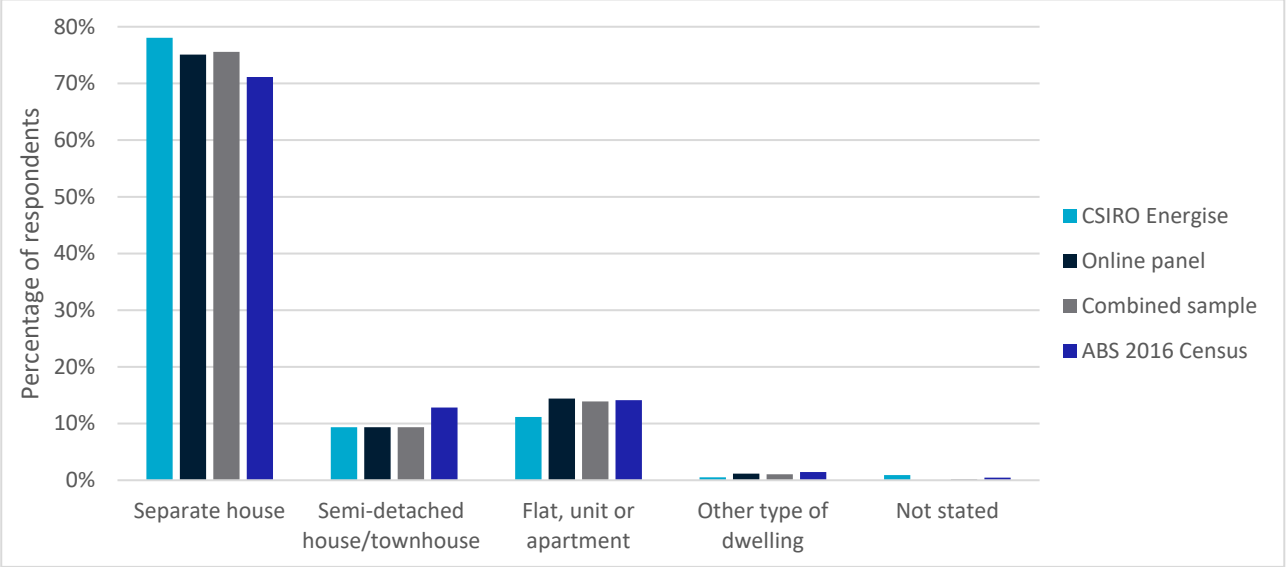


Figure 3. Sample representativeness: dwelling type of survey respondents (n=4,844) compared with the broader Australian population (based on 2016 ABS Census data)

Housing tenure

As shown in Figure 4, the combined survey sample had a higher proportion of home-owners (75%) and a lower proportion of renters (23%) compared with the broader Australian population based on ABS 2016 Census data (62% and 28%, respectively).

In addition, when comparing the two survey samples separately, it appears that the proportion of respondents within each housing tenure category varied between recruitment modes. For example, the proportion of owner-occupiers and renters in the online panel sample (73% and 24%, respectively) was more aligned with the ABS 2016 Census (62% and 28%, respectively) than the CSIRO Energise sample (86% and 12%, respectively).

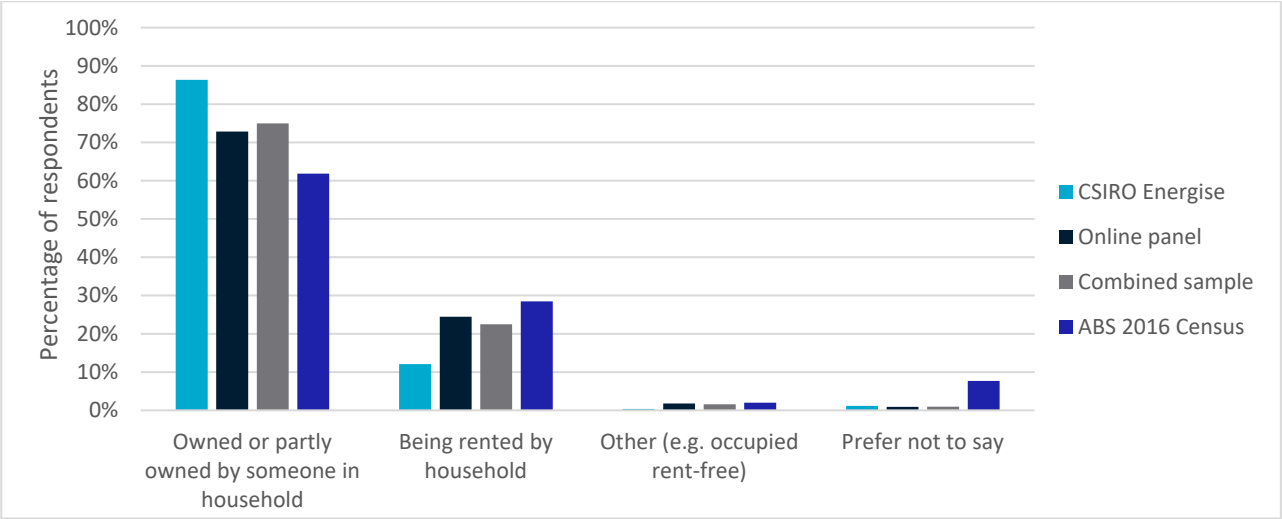


Figure 4. Sample representativeness: housing tenure of survey respondents (n=4,844) compared with the broader Australian population (based on ABS 2016 Census data)

Household size

As shown in Figure 5, the combined survey sample had higher proportion of respondents living in two-person households (47%) compared with the broader Australian population based on ABS 2016 Census data (33%). However, the proportion of survey respondents living in households with one person only (20%) or three or more persons (34%) was lower than that of the broader population based on ABS 2016 Census data (24% and 42%, respectively).

In addition, when comparing the two survey samples separately, it appears that the proportion of respondents within different household sizes varied slightly between recruitment modes. For example, the proportion of one- and three-person households in the online panel sample (20% and 14%, respectively) was more aligned with the ABS 2016 Census (24% and 16%, respectively) than the CSIRO Energise sample (16% and 12%, respectively).

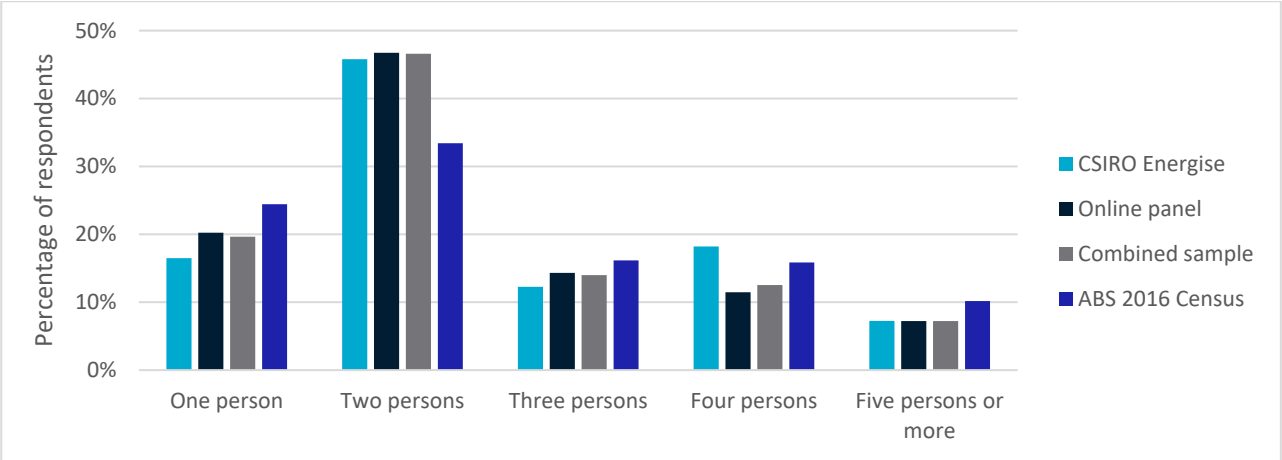


Figure 5. Sample representativeness: household size of survey respondents (n=4,810)[6] compared with the broader Australian population (based on ABS 2016 Census data)

[6] Excludes 34 respondents who did not report the number of occupants in their household.

Household composition

As shown in Figure 6, the combined survey sample had higher proportion of couples without children (38%) compared with the broader Australian population (25%), based on ABS 2016 Census data. Conversely, the proportion of survey respondents who described themselves as lone person households (19%), couples with children (28%), or one parent families with children (7%) was lower than that of the broader Australian population (23%, 30% and 10%, respectively).

In addition, when comparing the two survey samples separately, it appears that the proportion of respondents within each household composition category varied between recruitment modes. For example, the online panel sample appears to be more aligned with the ABS 2016 Census than the CSIRO Energise sample for lone person households (15% CSIRO Energise vs. 20% online panel vs 23% ABS 2016 Census), one parent families with children (3% CSIRO Energise vs. 7% online panel vs. 10% ABS 2016 Census) and group households (2% CSIRO Energise vs. 4% online panel vs. 4% ABS 2016 Census). The online panel sample was also slightly more aligned with the ABS 2016 Census than the CSIRO Energise sample for couples without children (41% CSIRO Energise vs. 38% online panel vs. 25% ABS 2016 Census).

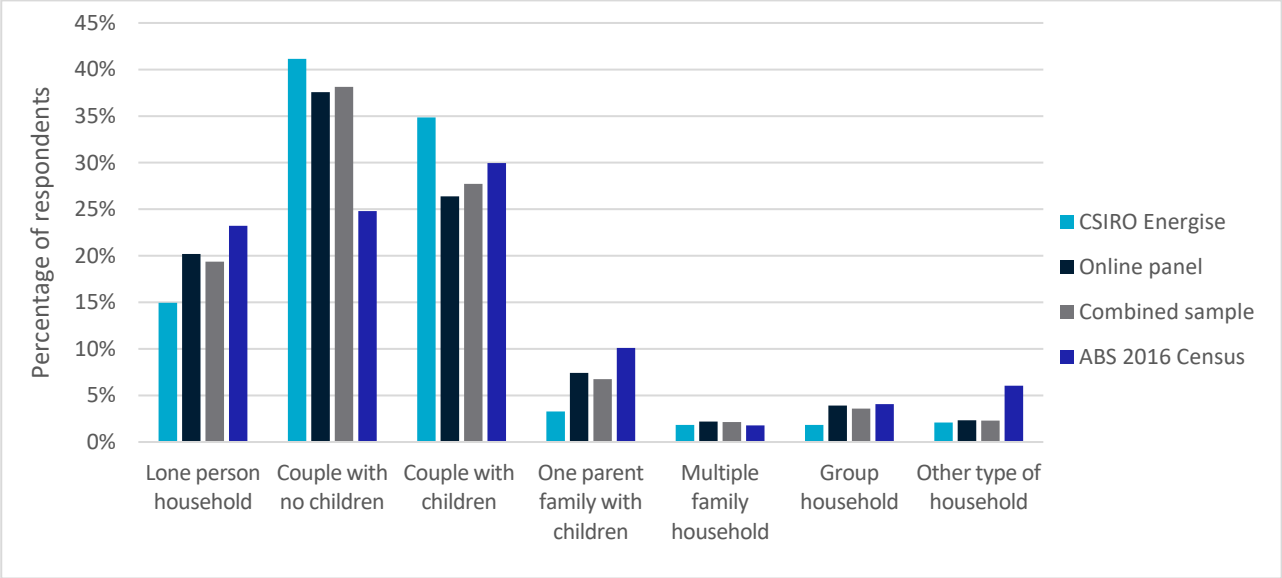


Figure 6. Sample representativeness: household type of survey respondents (n=4,824)[7] compared with the broader Australian population (based on ABS 2016 Census data)

Household income

As shown in Figure 7, the combined survey sample had a slighter higher proportion of respondents with total household incomes under $104,000 per annum (64%) when compared with the broader Australian population (58%), based on ABS 2016 Census data. However, the proportion of survey

[7] Excludes 20 respondents who did not report their type of household.

respondents with total household incomes of $130,000 or more per annum (17%) was slightly lower than that of the broader Australian population (21%).

In addition, when comparing the two survey samples separately, it appears that the proportion of respondents within each household income category varied between recruitment modes. For example, the online panel sample appears to be more aligned with the ABS 2016 Census than the CSIRO Energise sample for respondents with household incomes below $78,000 per annum (30% CSIRO Energise vs. 55% online panel vs. 47% ABS 2016 Census) and above $130,000 per annum (34% Queensland vs. 14% online panel vs. 34% ABS 2016 Census).

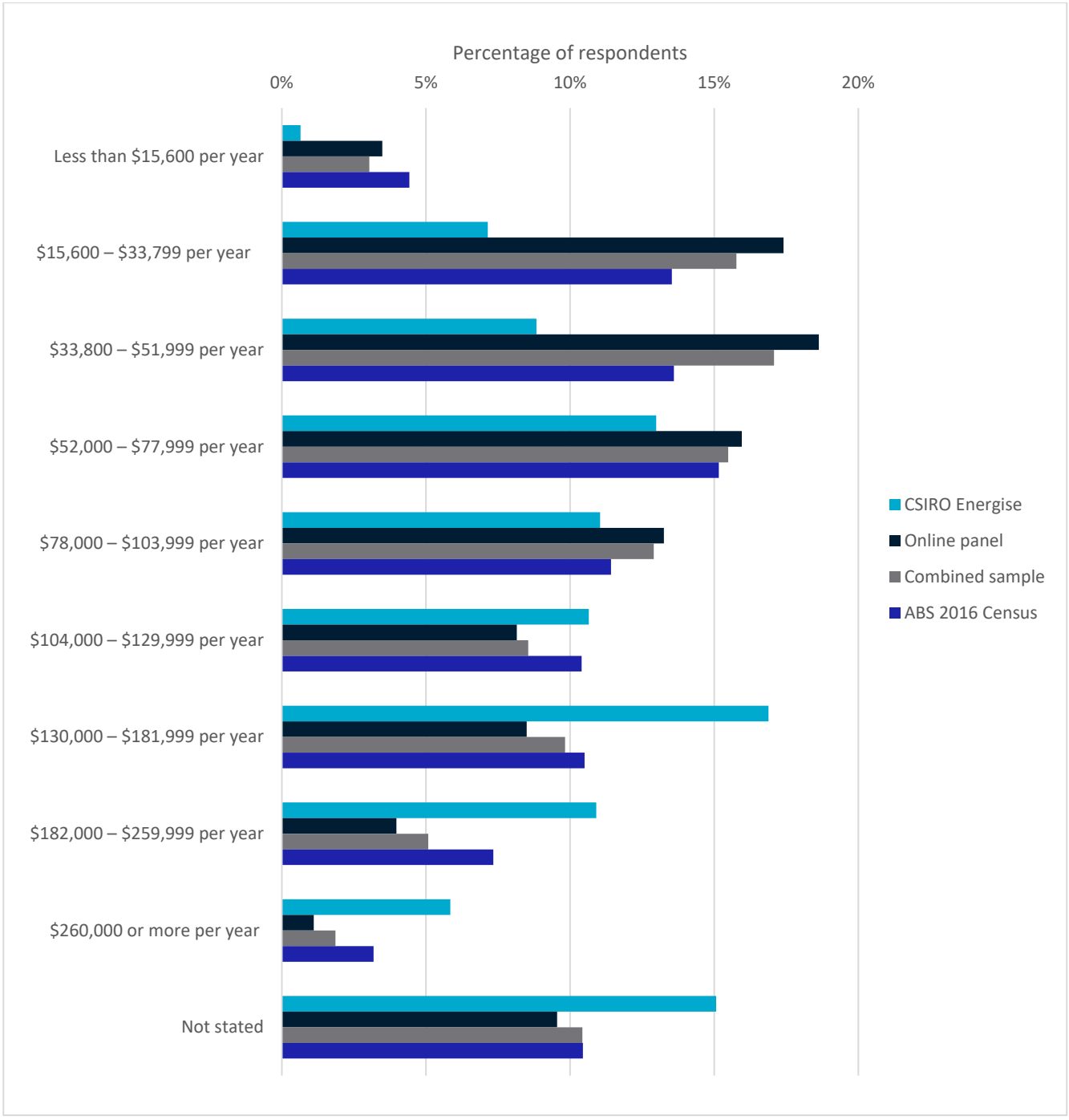


Figure 7. Sample representativeness: household income of survey respondents (n=4,844) compared with the broader Australian population (based on ABS 2016 Census data)

2.3 Analytical approach

A range of statistical methods were used to analyse the data collected through the two surveys:

- First, basic descriptive statistics (e.g. frequencies, percentages, means, standard deviations, etc.) were computed to explore the survey data, including a series of cross-tabulations using selected socio-demographic and dwelling variables. Section 3 presents the results from these descriptive analyses, with a focus on exploring whether any differences exist between survey respondents who reported using wood (herein referred to as 'firewood users') or not using wood (herein referred to as 'non-firewood users') as an energy source.
- Second, a hierarchical regression analysis was conducted to identify the key predictors of residential firewood consumption in Australia. The primary purpose of this analysis was to better understand which factors are most vs. least important for explaining variability in self-reported wood consumption across households – insights that may prove valuable for future research in this domain. Section 4 presents the results from this analysis, with a focus on exploring the contribution of geographical, demographic, dwelling-related and behavioural variables to explaining variability in firewood consumption.
- Third, a step-wise process was followed to compute estimates of residential firewood consumption for each state and territory of Australia. This process drew on multiple data sources to produce up-to-date estimates of residential firewood consumption for the nation, using a new methodology that extends on the CSIRO's earlier work in this area. Section 5 presents the results from this analysis, with a focus on comparing the current estimates with earlier research and data sources on firewood use in Australia.
- Finally, a preliminary analysis of longitudinal (i.e. repeated measures) data was conducted to explore changes in self-reported firewood consumption patterns over time, with results presented in Section 6.

3 Descriptive survey results

Prior to conducting the main analyses to estimate residential firewood consumption, preliminary analyses of the survey data were undertaken to investigate the relationships between key variables and explore what factors explain variability in firewood use across households. In this section, we summarise some key findings from these preliminary analyses, including descriptive results for each survey question. We also present the outcomes from a series of cross-tabulations with selected geographical, demographic and dwelling characteristics to explore what differences exist between respondents who reported using firewood as an energy source at home (i.e. firewood users) and those who reported not using firewood at home (i.e. non-firewood users).

3.1 Residential firewood use in Australia

First, basic descriptive statistics and cross-tabulations were computed to explore firewood use as a function of different geographical, demographic and dwelling characteristics, such as location, dwelling type and age, housing tenure, household size and type, income level, and other energy sources used by households. Unless otherwise specified, the results in this sub-section are based on the total sample of respondents (i.e. CSIRO Energise survey and online panel survey combined).

Geographical location

Overall, about one quarter of our sample (24%) reported using firewood as an energy source at home. As shown in Figure 8, the proportion of firewood users varied across states and territories. Rates of firewood use were highest among those living in Tasmania (38%), Victoria (28%), Western Australia (27%), South Australia (25%) and lower for those in New South Wales (23%), the Northern Territory (22%), Australian Capital Territory (18%) and Queensland (17%).

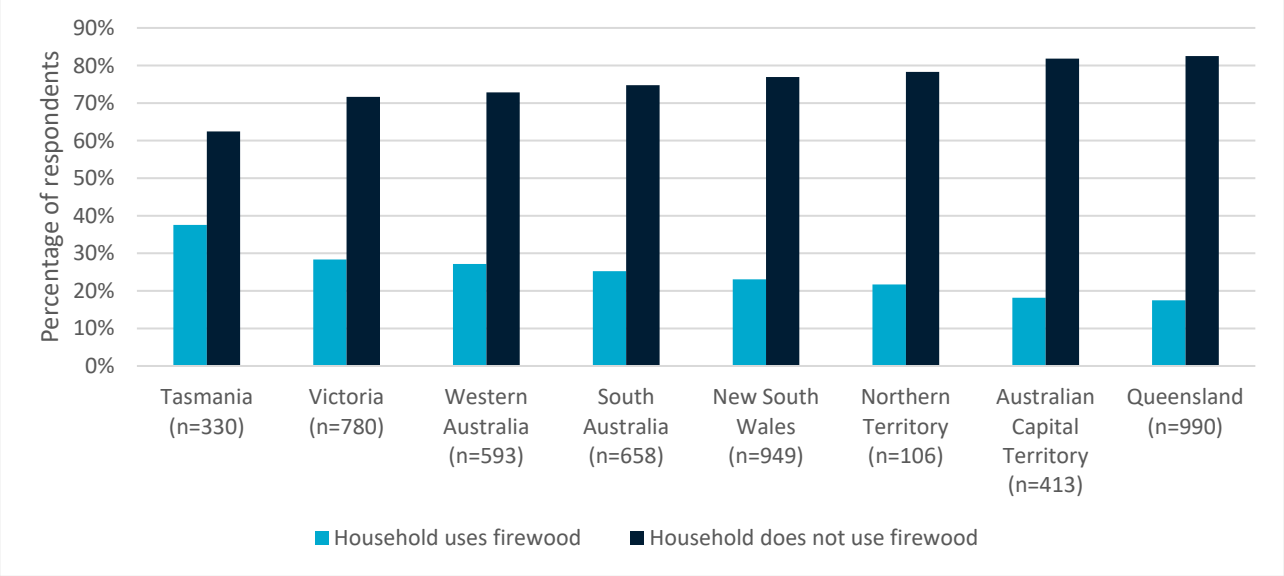


Figure 8. Proportion of survey respondents who reported using (vs. not using) firewood in each state and territory

In addition, across most Australian states and territories (with the exception of Queensland), the percentage of firewood users was noticeably lower in capital cities than outside of capital cities. For example, Table 3 below shows rates of firewood use across ABS Greater Capital City Statistical Areas (GCCSA). It can be seen that rates of firewood use are highest among those householders living outside of capital cities – more specifically, households in Rest of Western Australia (50%), Rest of Tasmania (46%), Rest of South Australia (39%) and Rest of Victoria (35%). In contrast, the highest proportions of firewood use among those living in a capital cities were reported by survey respondents in Hobart (27%), Melbourne (25%) and Adelaide (21%), respectively.

Table 3. Distribution of the survey samples (firewood users vs. non-firewood users) across Greater Capital City Statistical Areas

GREATER CAPITAL CITY STATISTICAL AREA (GCCSA)	HOUSEHOLD USES FIREWOOD		HOUSEHOLD DOES NOT USE FIREWOOD	
	FREQUENCY	PERCENTAGE	FREQUENCY	PERCENTAGE
Greater Hobart	40	27%	107	73%
Rest of Tasmania	84	46%	99	54%
Greater Melbourne	126	25%	384	75%
Rest of Victoria	95	35%	175	65%
Greater Perth	92	20%	362	80%
Rest of Western Australia	69	50%	70	50%
Greater Adelaide	105	21%	398	79%
Rest of South Australia	61	39%	94	61%
Greater Sydney	98	18%	437	82%
Rest of New South Wales	121	29%	293	71%
Greater Darwin	15	19%	65	81%
Rest of Northern Territory	8	31%	18	69%
Australian Capital Territory	75	18%	337	82%
Greater Brisbane	96	18%	441	82%
Rest of Queensland	76	17%	375	83%

Dwelling type

The proportion of firewood users also varied depending on dwelling type. As shown in Figure 9, the proportion of survey respondents living in separate houses was higher among firewood users (90%) than non-firewood users (71%), whereas the proportion living in semi-detached dwellings and units/apartments was higher among non-firewood users (28%) than firewood users (8%).

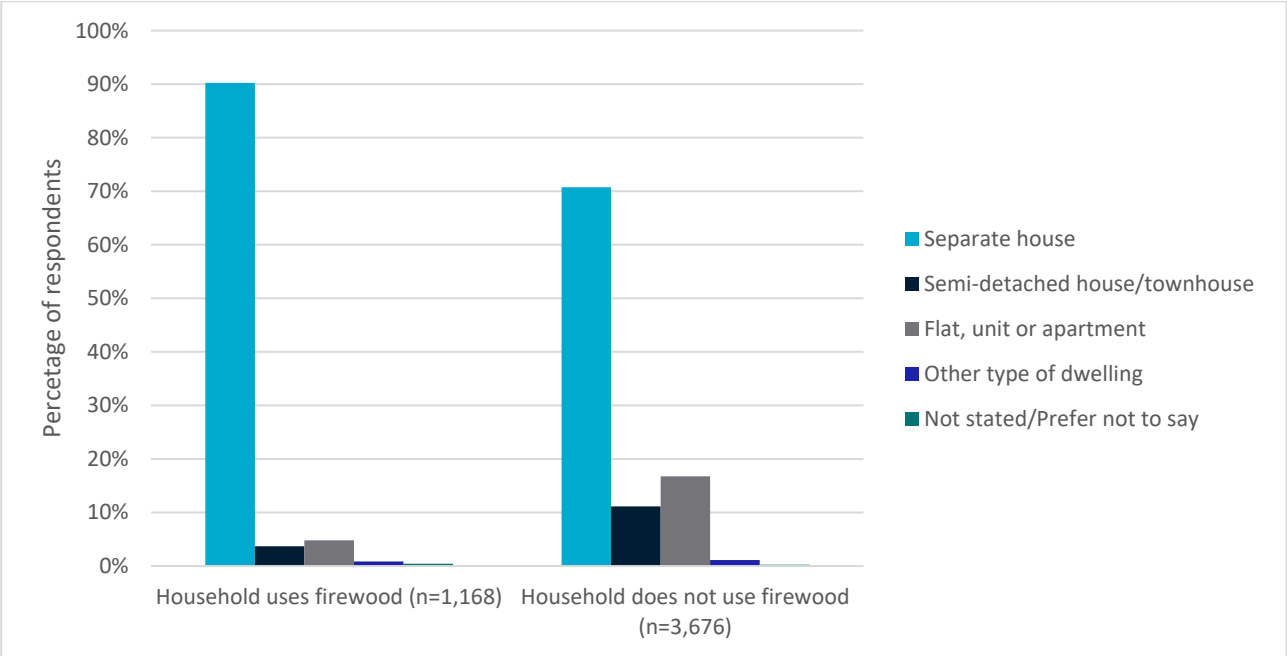


Figure 9. Proportion of survey respondents who reported using (vs. not using) firewood across different dwelling types

Dwelling age

As shown in Figure 10, the proportion of survey respondents who reported using firewood was higher among those living in dwellings constructed prior to the year 2000 (77%) compared to those living in dwellings constructed since 2000 (67%).

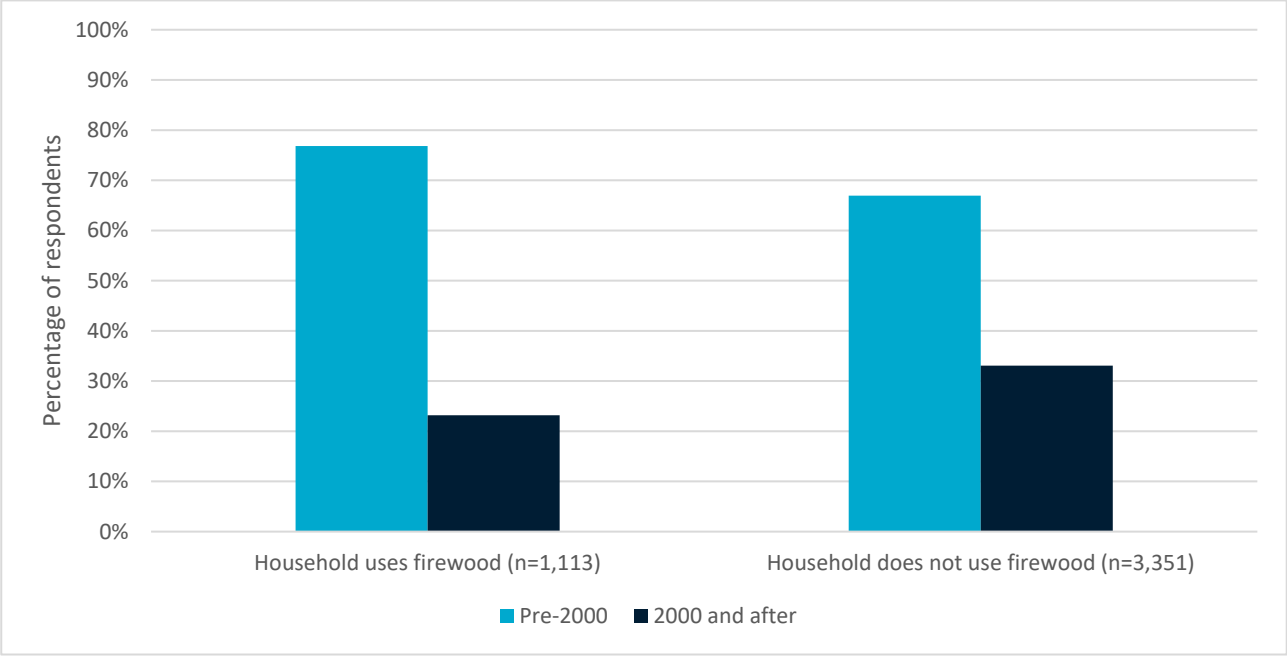


Figure 10. Proportion of survey respondents who reported using (vs. not using) firewood by dwelling age

Housing tenure

As shown in Figure 11, the proportion of survey respondents who reported living in owner-occupied dwellings was higher for firewood users (82%) than non-firewood users (73%), whereas the proportion who reported living in rented dwellings was higher for non-firewood users (24%) than firewood users (17%).

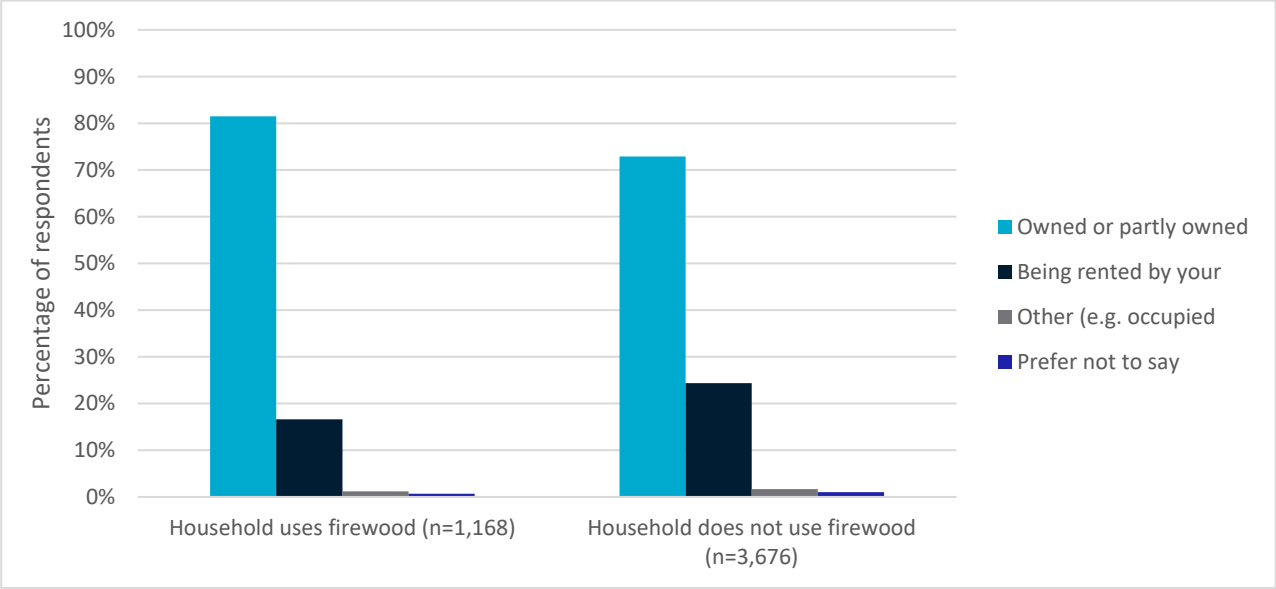


Figure 11. Proportion of survey respondents who reported using (vs. not using) firewood by housing tenure

Household size

As shown in Figure 12, the proportion of respondents who reported living in one- or two-person households was lower among firewood users (11% and 42%, respectively) than non-firewood users (22% and 48%, respectively). Conversely, the proportion who reported living in households with three or more persons was higher among firewood users (48%) than non-firewood users (29%).

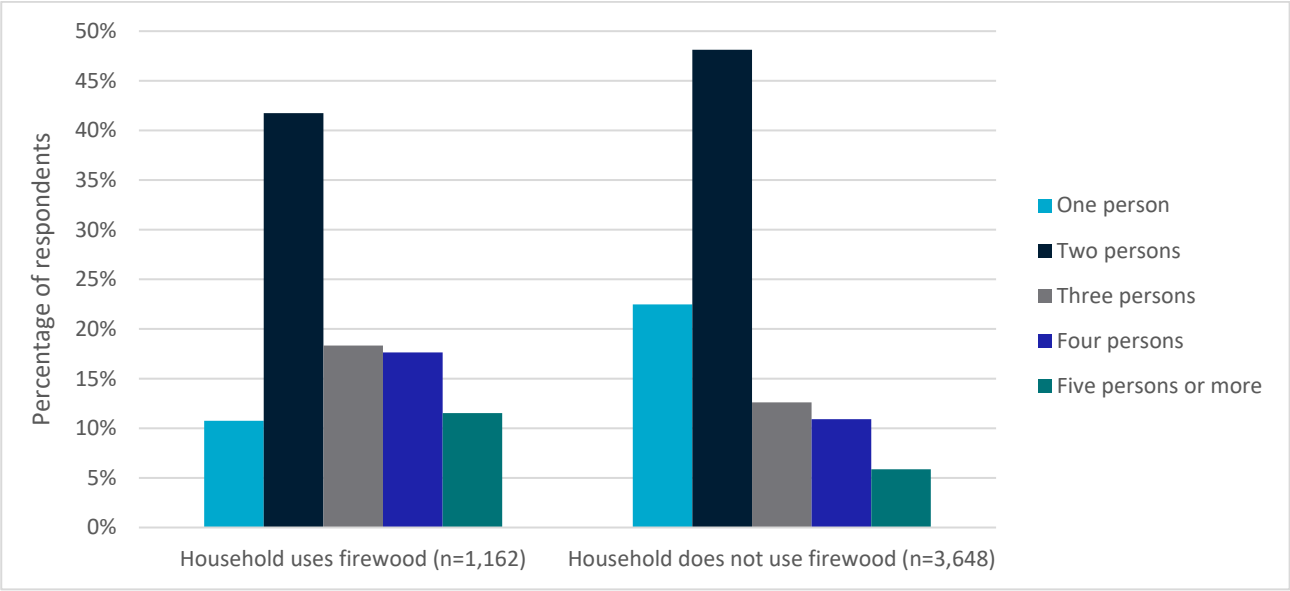


Figure 12. Proportion of survey respondents who reported using (vs. not using) firewood across different household sizes

Household composition

As shown in Figure 13, the proportion of survey respondents who described themselves as lone-person households or couples without children was lower among firewood users (11% and 34%, respectively) than non-firewood users (22% and 39%, respectively). Conversely, the proportion who described themselves as a couple with children was higher among firewood users (38%) than non-firewood users (24%).

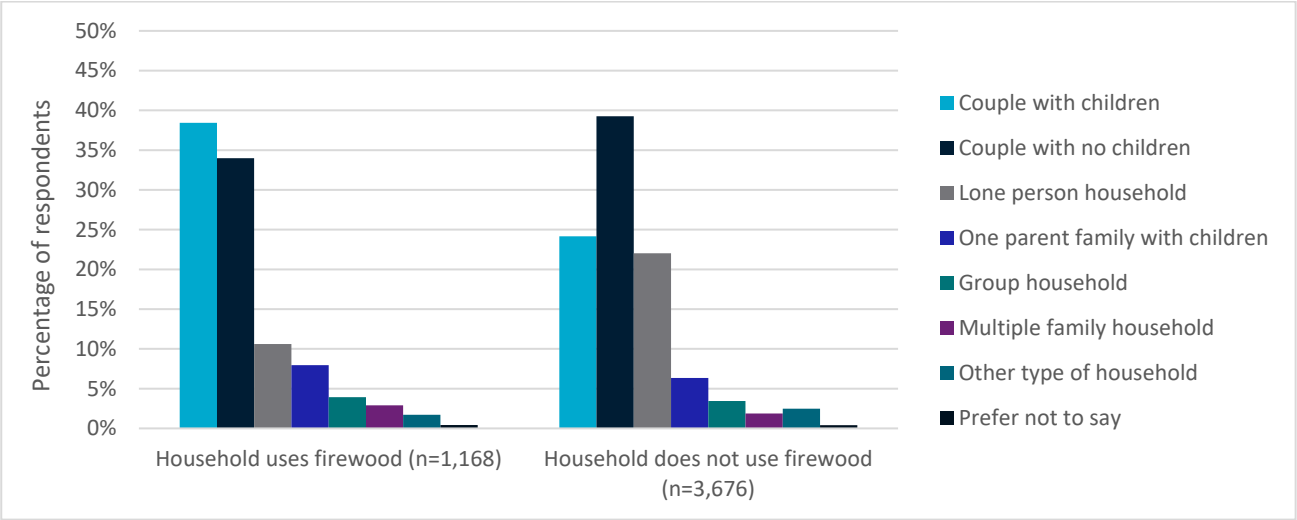


Figure 13. Proportion of survey respondents who reported using (vs. not using) firewood across different household types

Household income

As shown in Figure 14, in general, the proportion of survey respondents with total household incomes of $78,000 or more per annum was higher among firewood users (46%) than non-firewood users (36%). Conversely, the proportion who reported annual household incomes below $78,000 was lower among firewood users (46%) than non-firewood users (53%).

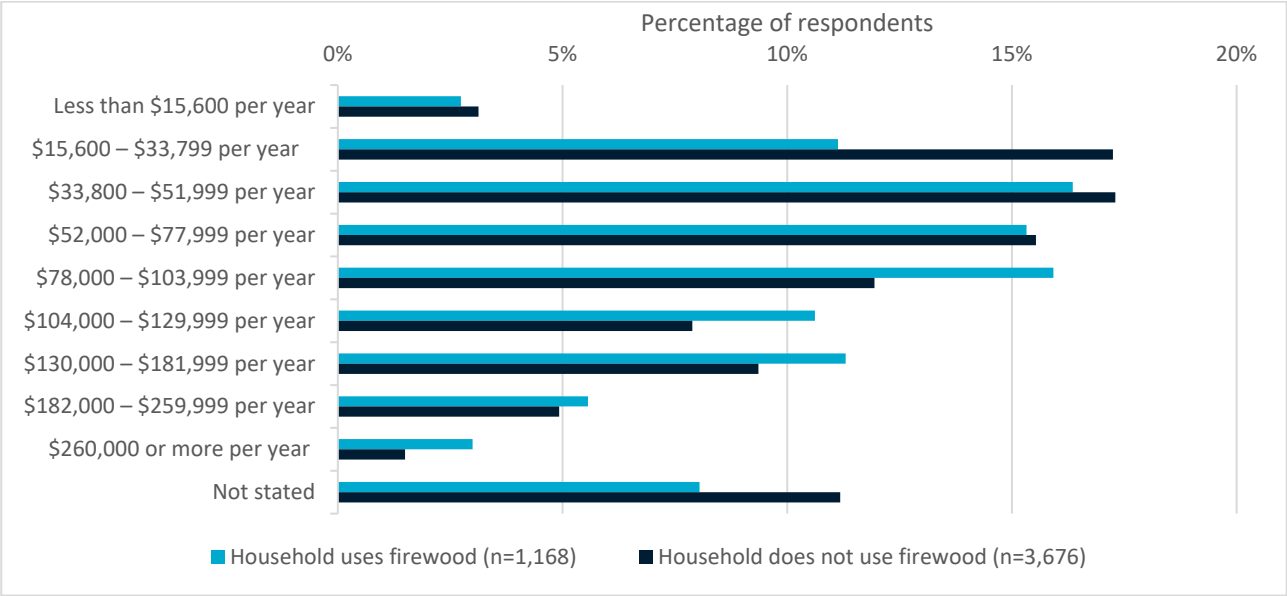


Figure 14. Proportion of survey respondents who reported using (vs. not using) firewood across different household income ranges

Household energy sources

Across the entire survey sample, almost all respondents (98%) reported using electricity as a power source, with just under one-half (47%) also using mains gas, one-fifth (20%) using bottled gas/LPG, and two-fifths (38%) using solar generated electricity. As described earlier, about one-quarter (24%) also reported using firewood at home. However, the use of firewood varied across households depending on what other energy sources were used. As shown in Figure 15, firewood use was comparatively higher among respondents who also reported using bottle gas/LPG (39%) or solar (29%), but comparatively lower among those who also reported using mains gas (21%).

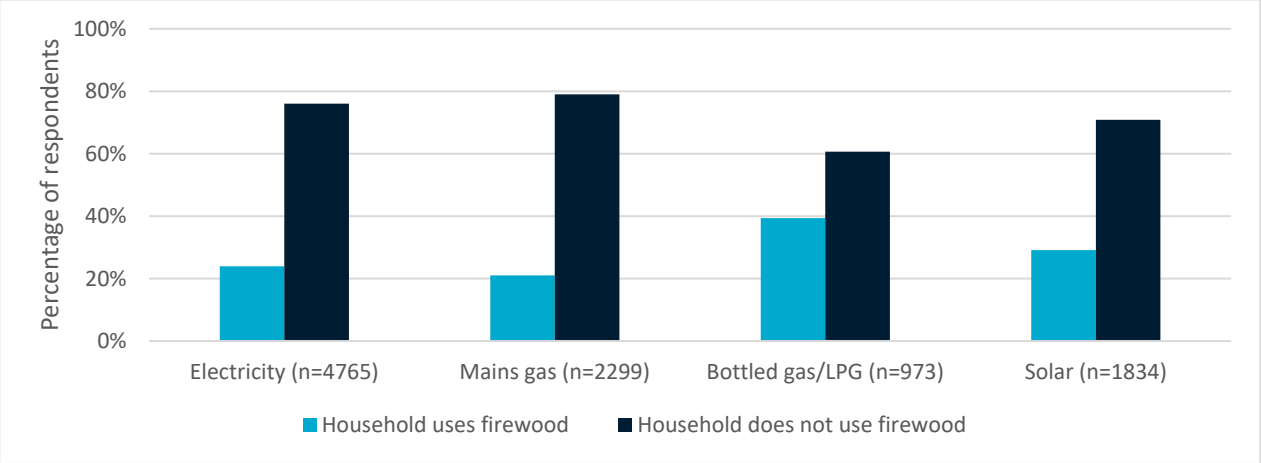


Figure 15. Proportion of survey respondents who reported using (vs. not using) firewood as a function of different energy sources

3.2 Wood-fired appliances

Second, descriptive statistics were computed to explore the ownership and usage of wood-fired appliances by households, including recent and future purchases of such appliances. In this sub-section, the results on past and future purchases of wood-fired appliances pertain to the entire sample of survey respondents, regardless of whether wood is used an energy source. However, the results on the number of wood-fired appliances currently used by households pertain only to the sub-sample of survey respondents who reported using firewood as an energy source at home.

Past purchases of wood-fired appliances

All survey respondents, including both firewood users and non-firewood users, were asked about their recent purchases of wood-fired appliances. As shown in Figure 16, most respondents (89%) indicated that they had not purchased a firewood appliance in the past five years.

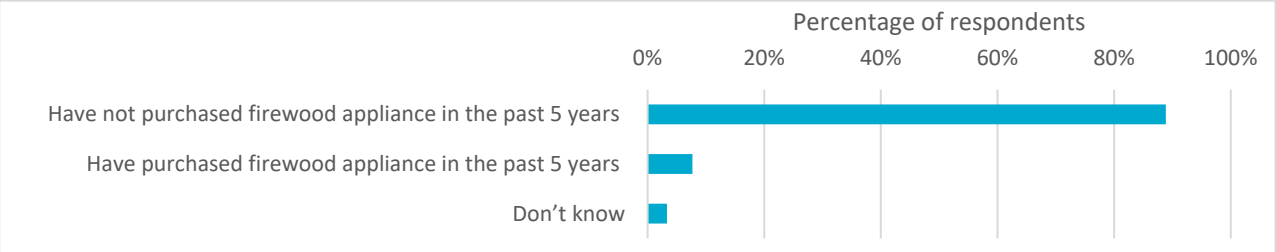


Figure 16. Recent purchases of wood-fired appliances (n=4,841)

Intention to purchase wood-fired appliances in the future

All survey respondents were also asked about their plans to purchase wood-fired appliances in the future. As shown in Figure 17, most respondents (78%) indicated no intention to buy or install any wood-fired appliances. Small numbers expressed an intention to purchase wood-fired appliances in the short-term (6%), medium-term (4%) or long-term (3%) future.

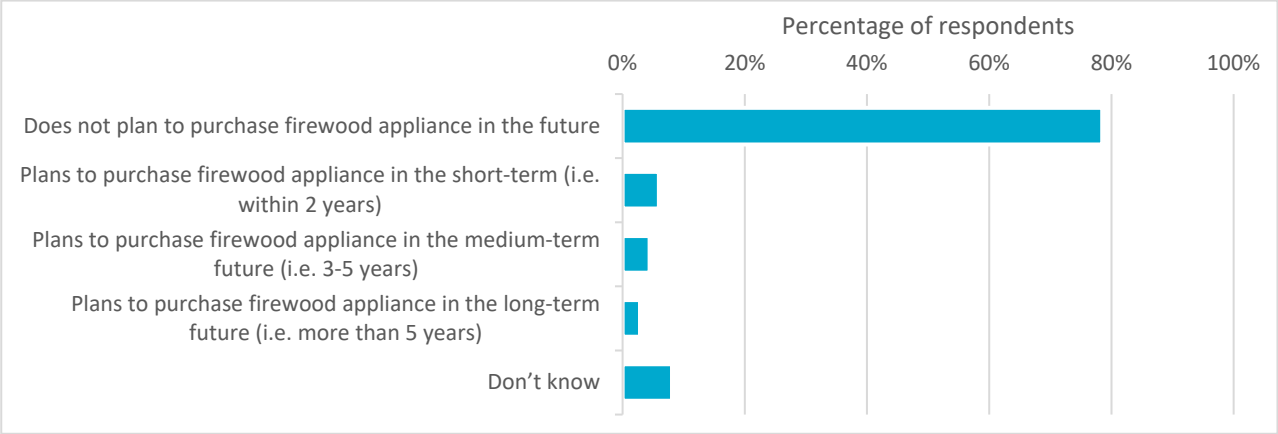


Figure 17. Intentions to purchase wood-fired appliances in the future (n=4,842)

Number of wood-fired appliances currently used

Those survey respondents who reported using wood as an energy source at home were asked to indicate the total number of wood-fired appliances currently used by their households. As shown in Figure 18, among the sub-sample of survey respondents who reported using firewood, most (65%) reported using one wood-fired appliance at home. Almost one-quarter (24%) reported using two wood-fired appliances, with the remainder (11%) using three or more.

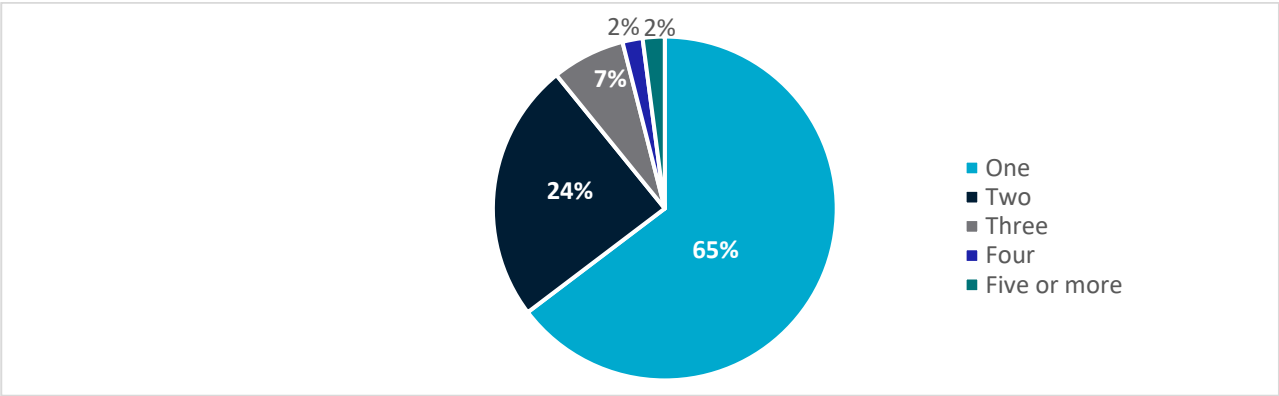


Figure 18. Number of wood-fired appliances used at home by those who use wood as an energy source (n=1,161)

3.3 Firewood characteristics

Third, descriptive statistics and cross-tabulations were also compiled to explore the methods households typically use to source firewood, as well as the type(s) of wood they consume. Unless otherwise specified, the results presented in this sub-section pertain to the sub-sample of survey respondents who reported using firewood as an energy source at home; thus, those respondents who reported not using firewood are excluded from the results presented below.

Source of firewood

As shown in Figure 19, among the sub-sample of survey respondents who reported using firewood as an energy source, the most commonly cited way of sourcing firewood was self-collection (reported by 55% of firewood users), followed by purchasing firewood from a commercial supplier/shop (33%), buying it from a private seller (31%), and receiving firewood for free from others (28%). The remaining respondents reported sourcing firewood in other ways.

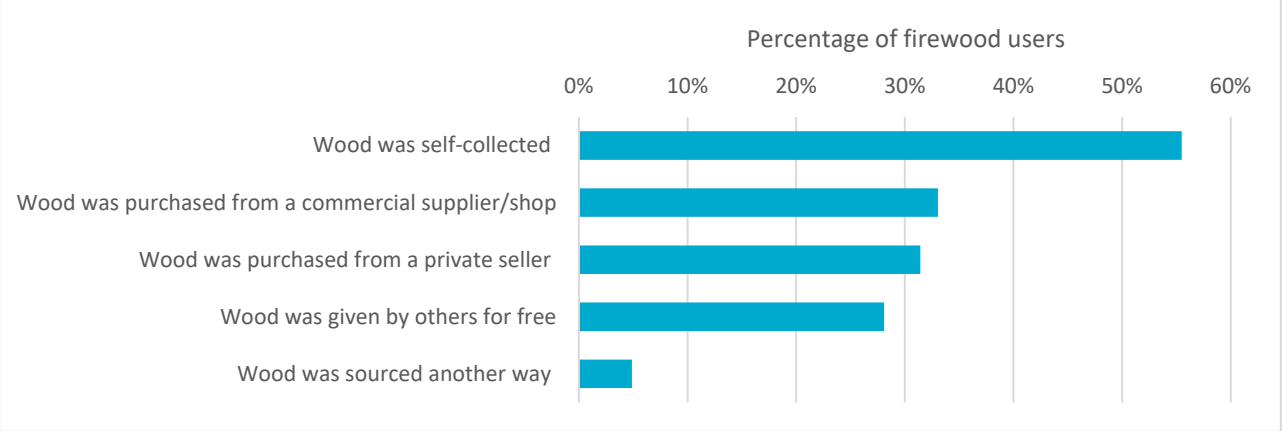


Figure 19. Methods of sourcing firewood (n=1,168)

As shown in Figure 20, the self-reported methods of sourcing firewood vary across geographical locations. Specifically, among the sub-sample of firewood users, a larger proportion of survey respondents living in major Australian cities reported purchasing firewood from a commercial supplier/shop (27%) compared to those living in inner regional (18%), outer regional (11%), and/or remote or very remote areas of Australia (19%). On the other hand, self-collection of firewood was more commonly cited by those living in remote or very remote (53%), outer regional (46%) and/or inner regional (38%) areas compared to those living in major Australian cities (31%)[8].

Figure 20. Methods of sourcing firewood across different geographical locations

[8] For this analysis, the ABS 'Australian Statistical Geography Standard (ASGS) remoteness structure' was used. For more details about the ABS classification, see: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/remoteness+structure

Type of firewood used

As shown in Figure 21, among the sub-sample of survey respondents who reported using firewood as an energy source at home, the majority (84%) reported using hardwoods. In contrast, only one-quarter (25%) reported using softwoods.

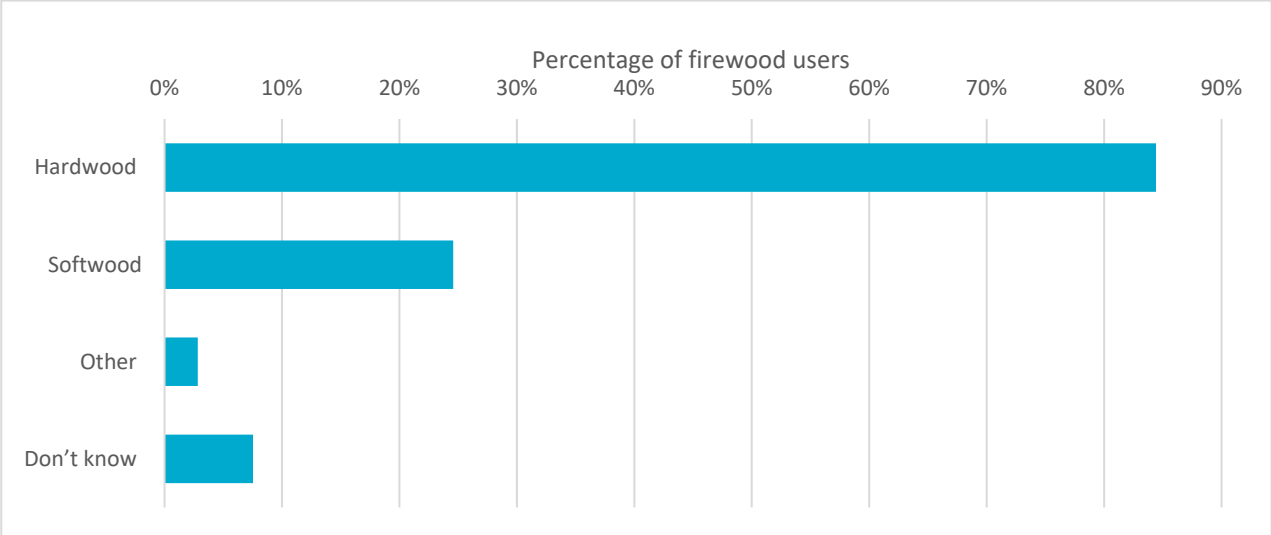


Figure 21. Type of firewood used at home (n=1,168)

Use of recycled wood/offcuts

As shown in Figure 22, among the sub-sample of survey respondents who reported using firewood at home, just under one-quarter (23%) indicated that recycled wood/offcuts comprised at least half of all firewood used by their household. Most respondents indicated that either none (23%) or less than one-quarter (32%) of all firewood used by their household was recycled/offcuts.

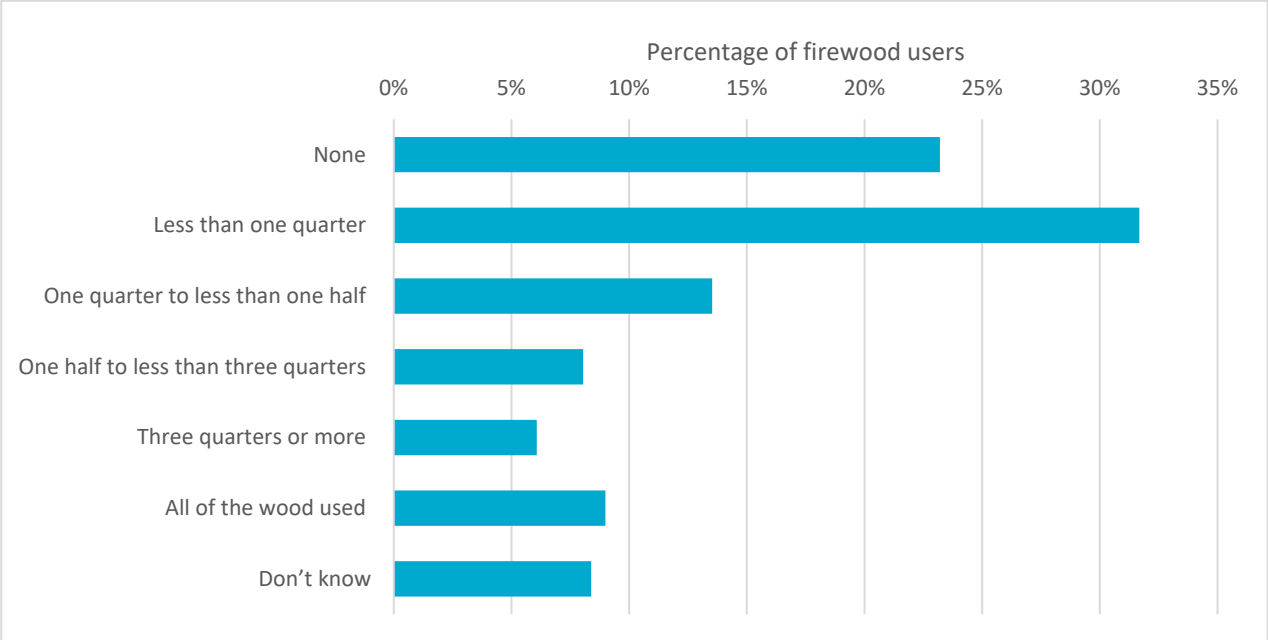


Figure 22. Use of recycled wood/offcuts for firewood (n=1,168)

3.4 Use of firewood for indoor space heating

Fourth, descriptive statistics and cross-tabulations were computed to explore the use of firewood for the specific purpose of indoor space heating. Unless otherwise specified, the results presented in this sub-section pertain to the sub-sample of survey respondents who reported using firewood as an energy source at home; thus, those survey respondents who reported not using firewood are excluded from the results presented below.

Geographical location

Among the sub-sample of survey respondents who used firewood as an energy source, the vast majority reported using firewood for indoor space heating. As shown in Figure 23, this pattern was evident across all states and territories of Australia, except for the Northern Territory where only about two-in-five (39%) firewood users reporting using firewood for indoor space heating.

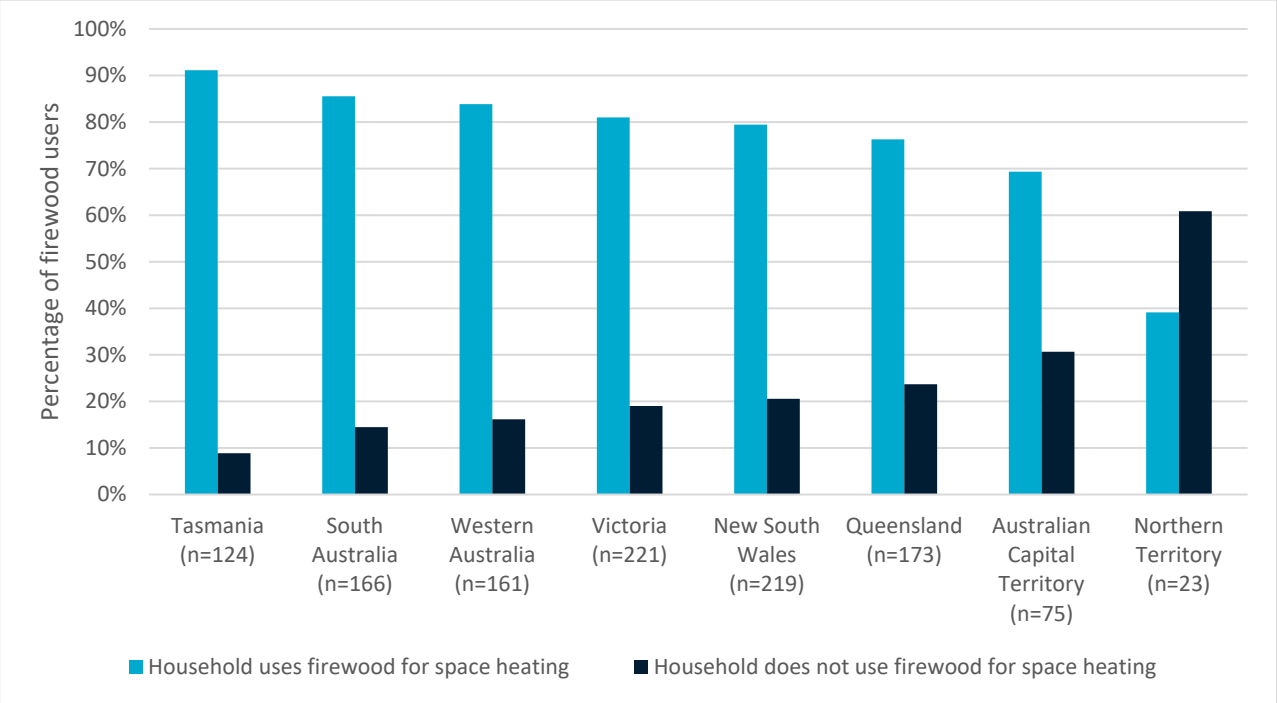


Figure 23. Use of firewood for indoor heating across states and territories (for the sub-sample of firewood users)

There were also differences in the use of firewood for indoor space heating depending on whether the respondent lived in a major city, regional or remote location[9]. As shown in Figure 23, among the sub-sample of firewood users who live in major cities, the proportion of respondents who reported using firewood for indoor space heating was lower than the proportion who reported not using firewood for space heating. On the other hand, this trend was the opposite direction for those living in inner regional and outer regional Australia. In these areas, the proportion of firewood users who used firewood for indoor space heating was greater than the proportion who

[9] For this analysis, the ABS 'Australian Statistical Geography Standard (ASGS) remoteness structure' was used. For more details about the ABS classification, see: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/remoteness+structure

did not use firewood for indoor space heating. Sample sizes for those living in remote and very remote Australia were too small to offer statistically significant insights.

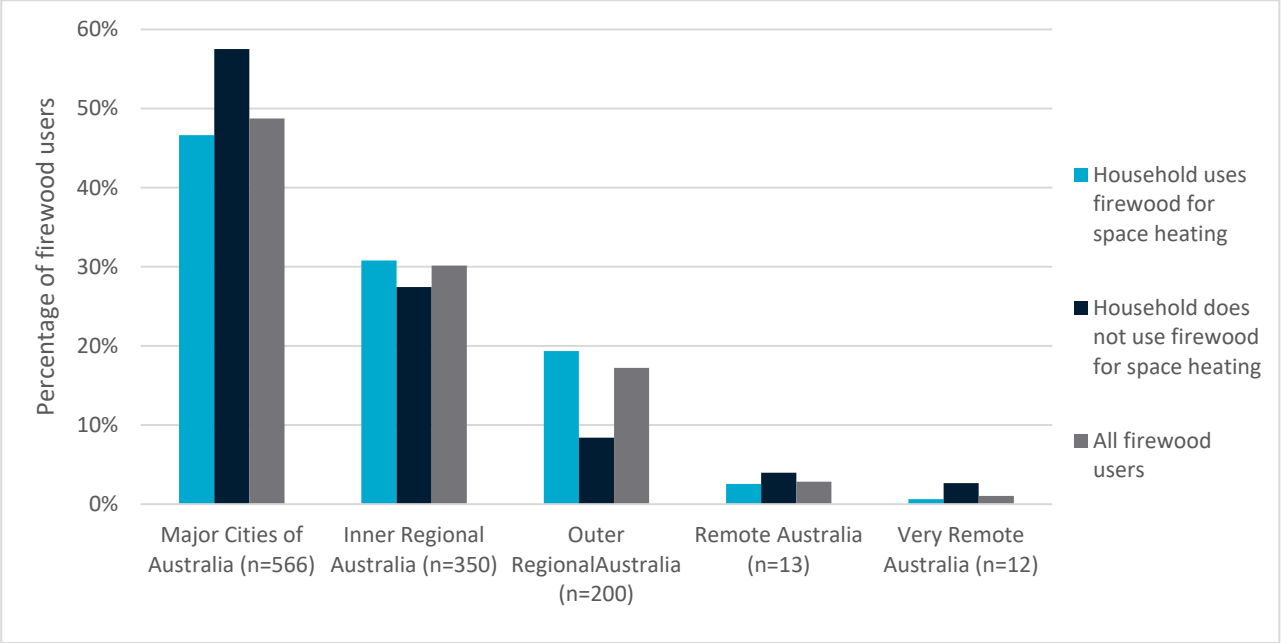


Figure 24. Use of firewood for indoor heating across geographical locations (for the sub-sample of firewood users)

Main type of indoor space heating

Among the sub-sample of survey respondents who reported using firewood for indoor space heating, about two-thirds (69%) stated that wood heating was the main type of home heating used by their household. As shown in Figure 25, however, there were some differences across states and territories. For example, the proportion who described wood heating as their main type of indoor space heating was lower among those living in the Australian Capital Territory (46%), Northern Territory (56%) and Victoria (62%) relative to other parts of the country.

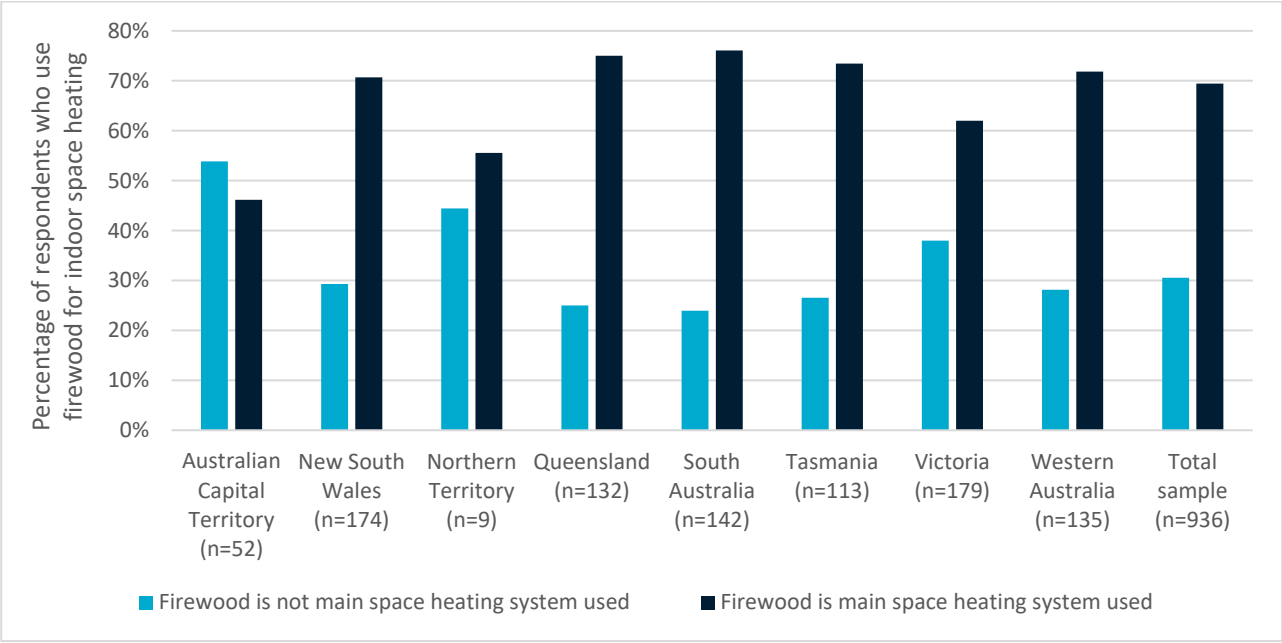


Figure 25. Use of firewood as the main type of indoor space heating across states and territories (for the sub-sample of firewood users who use firewood for indoor space heating)

Age of indoor space heating system

As shown in Figure 26, among the sub-sample of survey respondents who reported using firewood for indoor space heating, the proportion who used firewood as their main type of home heating was lower among those who acquired their heating system prior to 1992 (58%) compared to those who acquired their heating systems more recently.

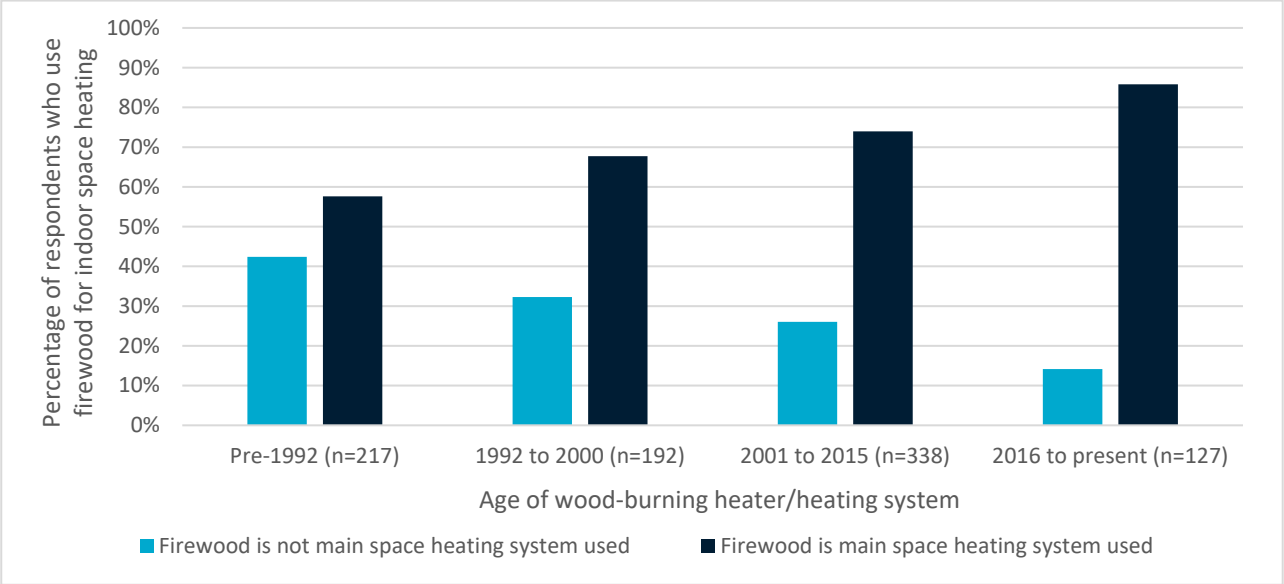


Figure 26. Use of firewood as the main type of indoor space heating by wood-heating system's age (for the sub-sample of firewood users who use firewood for indoor space heating)

Timing, frequency and duration of using firewood

Timing of using firewood for indoor space heating in winter

As shown in Figure 27, the use of firewood for indoor space heating is most common during the cooler months of the year, particularly May to September (peaking in the winter period). Among the sub-sample of survey respondents who use firewood for indoor space heating, more than half reported using wood-fired heating in winter (e.g. 52% in June, 57% in July and 52% in August).

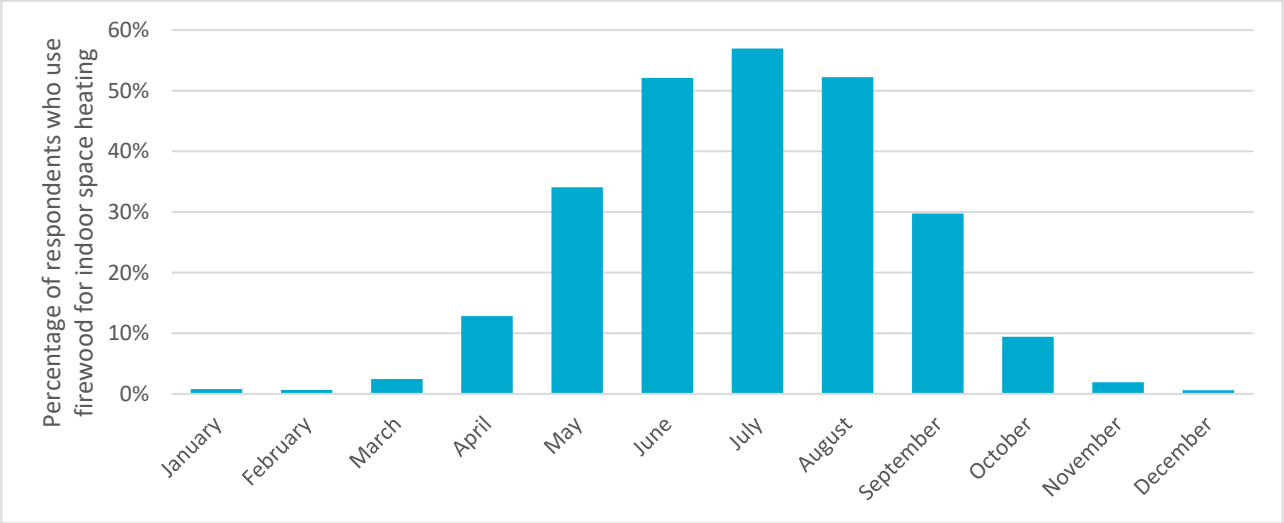


Figure 27. Use of firewood for indoor space heating across different months of the year (for the sub-sample of firewood users who use firewood for indoor space heating; n=1,520)

However, there are some geographical differences in the use of firewood for indoor space heating across different months of the year. As shown in Figure 28, Tasmania was the only state where the majority of respondents who use firewood for indoor heating reported using such heating during the months of May (62%) and September (61%).

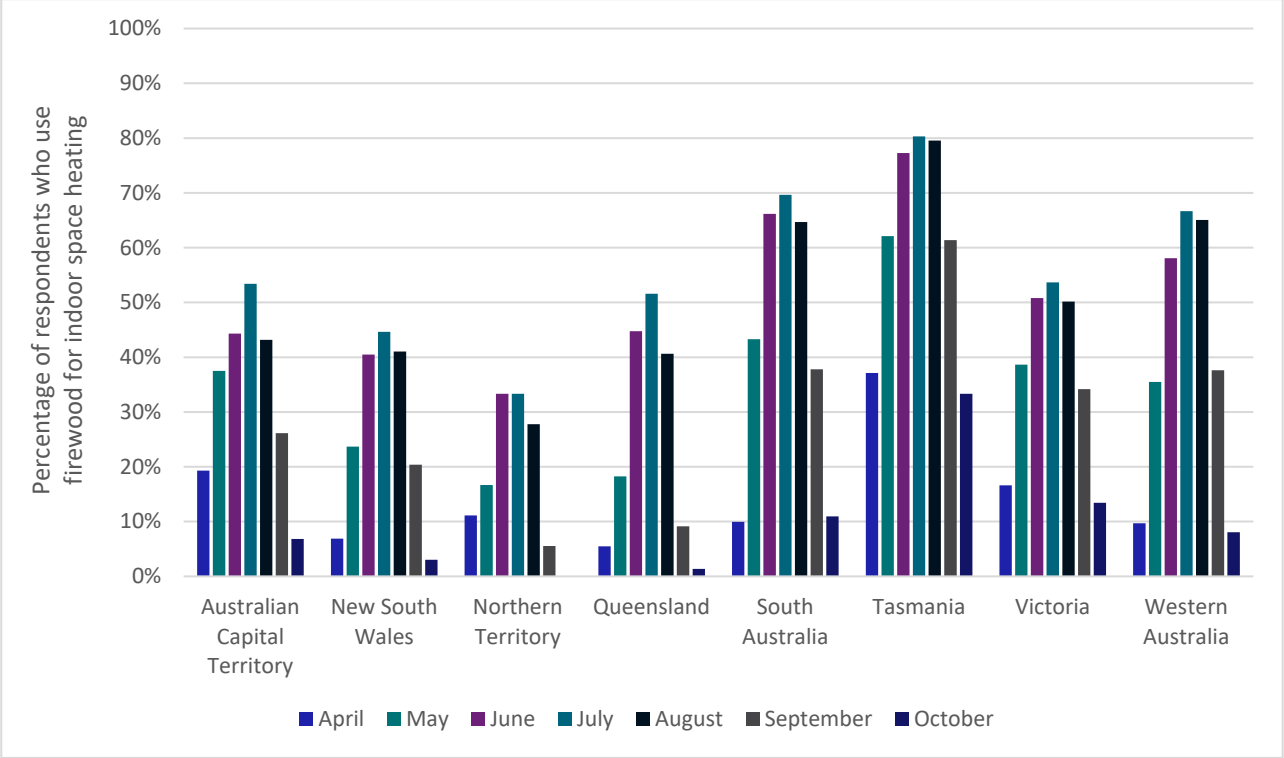


Figure 28. Use of firewood use for indoor space heating across different months of the year for each state and territory (for the sub-sample of firewood users who use firewood for indoor space heating n=1,520)

Frequency and duration of using firewood for indoor space heating in winter

The self-reported frequency and duration of using firewood for indoor space heating in winter also varies between states and territories. As shown in Figure 29 and Figure 30, among the sub-sample of respondents who reported using firewood for indoor space heating, those living in warmer areas – namely the Northern Territory and Queensland – reported less frequent use (in terms of the average number of days per week) and shorter use (in terms of the average number of hours per day) compared with other states and territories. Conversely, those living in Tasmania reported the highest frequency and duration of using firewood for indoor space heating during winter.

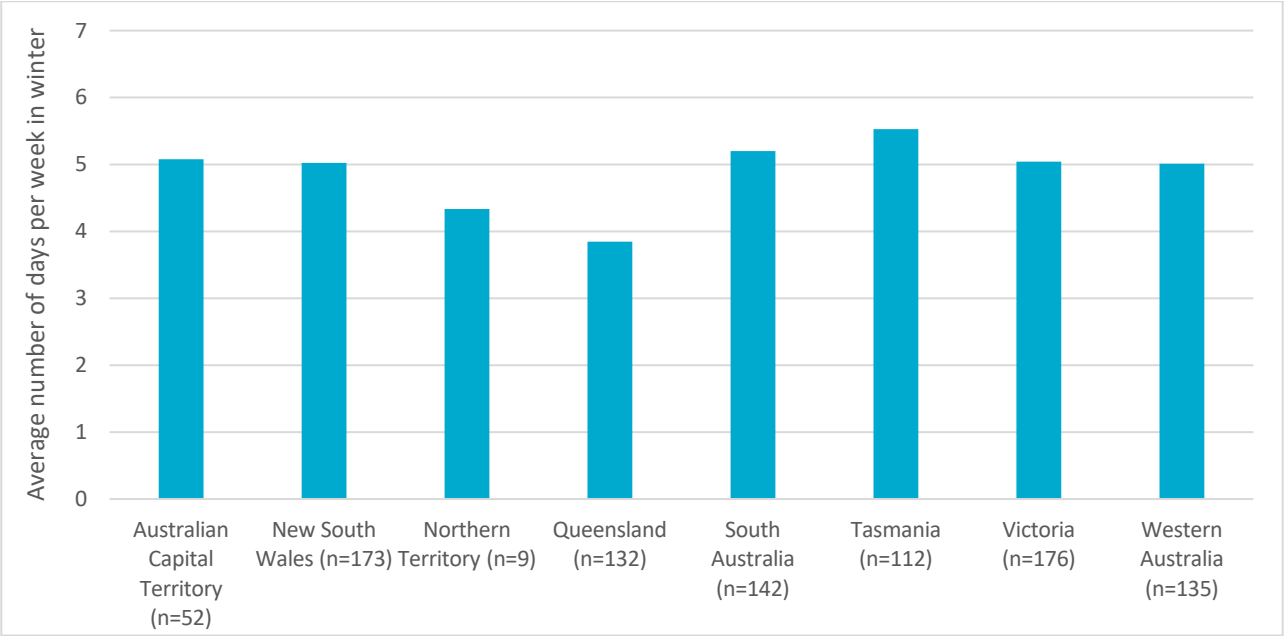


Figure 29. Average number of days per week firewood was used for indoor space heating in winter across state and territories (for the sub-sample of firewood users who use firewood for indoor space heating)

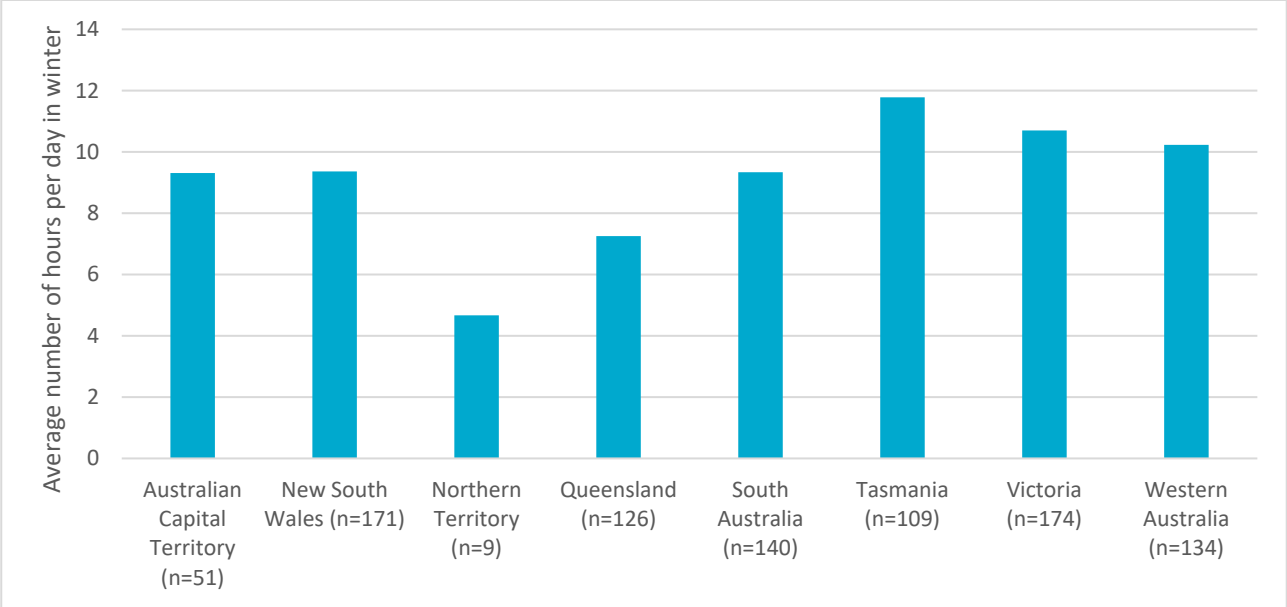


Figure 30. Average number of hours per day firewood was used for indoor space heating in winter across states and territories (for the sub-sample of firewood users who use firewood for indoor space heating)

Frequency and duration of using firewood for indoor space heating in the past week

As shown in Figure 31 and Figure 32, among the sub-sample of survey respondents who used firewood for indoor space heating, the self-reported frequency and duration of using firewood for indoor space heating in the week preceding the survey seemed to vary based on the date/time of survey completion. Perhaps unsurprisingly, in most Australian states and territories, those who completed the survey in August tended to report a higher frequency of use (i.e. number of days

per week) and duration of use (i.e. number of hours per day) compared to those who compelted the survey in September or October[10].

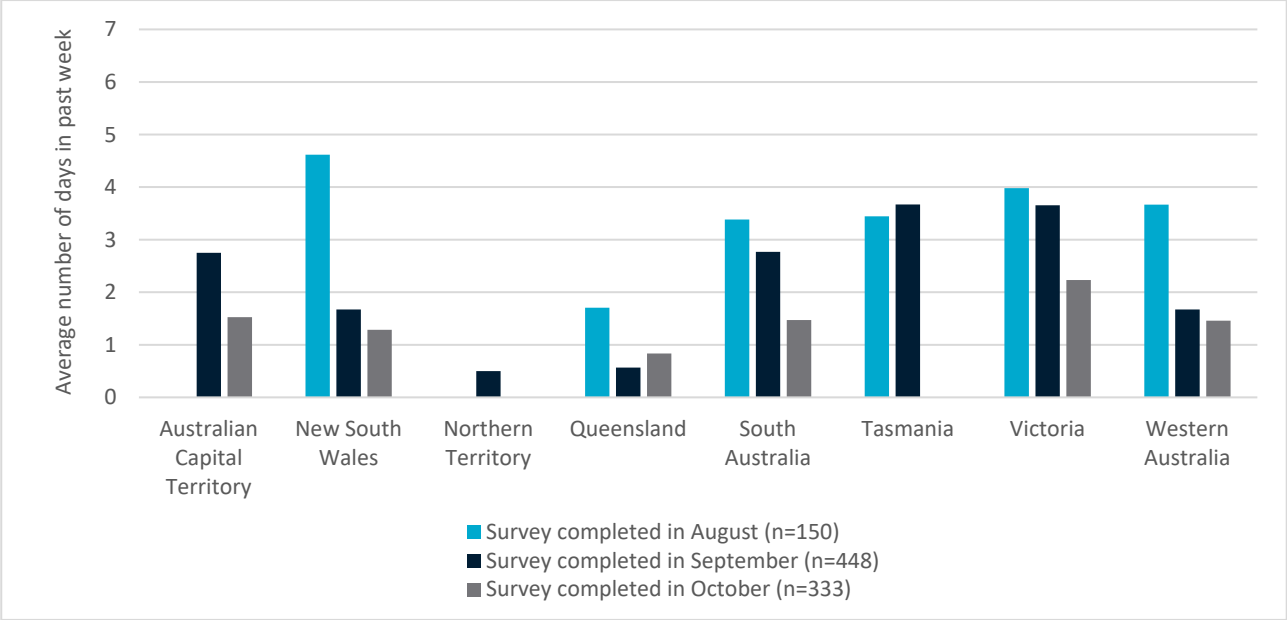


Figure 31. Average number of days firewood was used for indoor space heating in the week preceding the survey, and the timing of survey completion (for the sub-sample of firewood users who use firewood for indoor space heating)

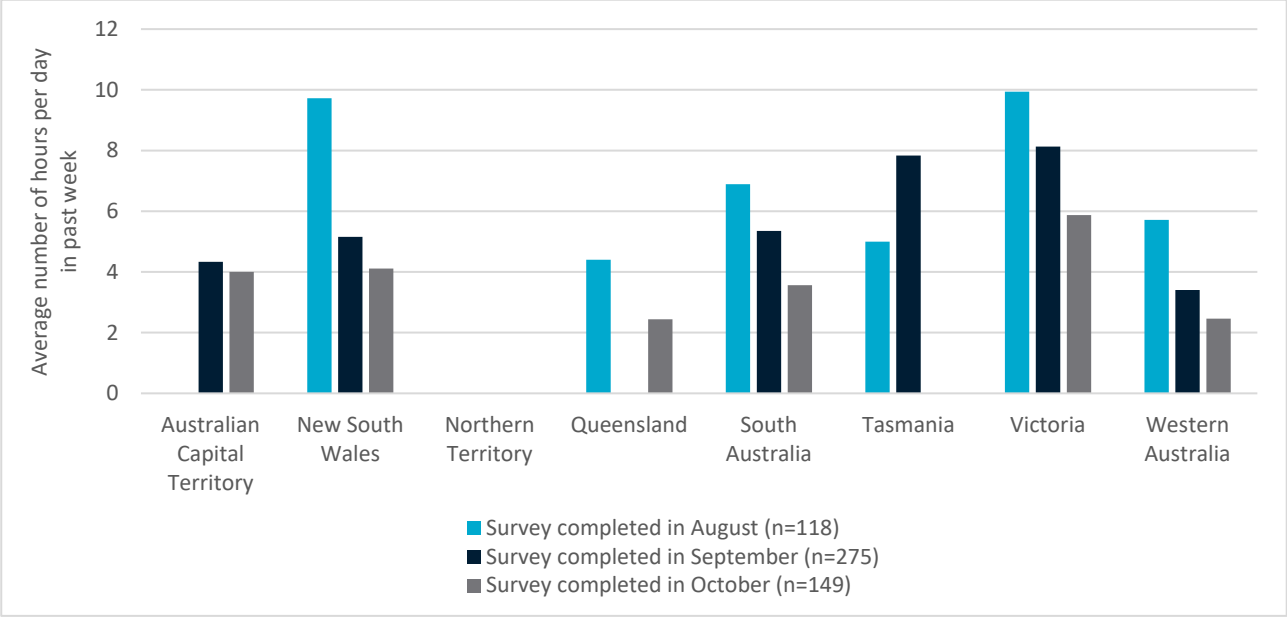


Figure 32. Average number of hours per day firewood was used for indoor space heating in the week preceding the survey, and the timing of survey completion (for the sub-sample of firewood users who use firewood for indoor space heating)

[10] Results are only presented for those cases where at least five survey responses were received for each combination of state/territory and month of survey completion.

3.5 Use of firewood for purposes other than indoor space heating

Descriptive statistics and cross-tabulations were also computed to explore the use of firewood for domestic purposes other than indoor space heating. Unless otherwise specified, the results in this sub-section pertain to the sub-sample of survey respondents who reported using firewood as an energy source at home; thus, those respondents who reported not using firewood are excluded from the results presented below.

Use of firewood for cooking, outdoor heating and hot water

As shown in Figure 33, the use of firewood for purposes such as cooking, outdoor heating and hot water seems to vary depending on whether or not the household also uses firewood for indoor space heating. To explain further, among those survey respondents who use firewood as an energy source at home (labelled sub-sample 1 in Figure 33), only a minority reported using firewood for hot water systems (9%), cooktops and/or ovens (12%), outdoor heating (23%), or outdoor BBQs/pizza ovens (33%). However, when comparing the responses of respondents who use firewood for indoor space heating (labelled sub-sample 1a in Figure 33) with the responses of respondents who do not use firewood for indoor space heating (labelled sub-sample 1b in Figure 33), it is evident that a higher proportion of respondents use firewood for outdoor activities (i.e. outdoor cooking/heating) when firewood is not used for indoor space heating.

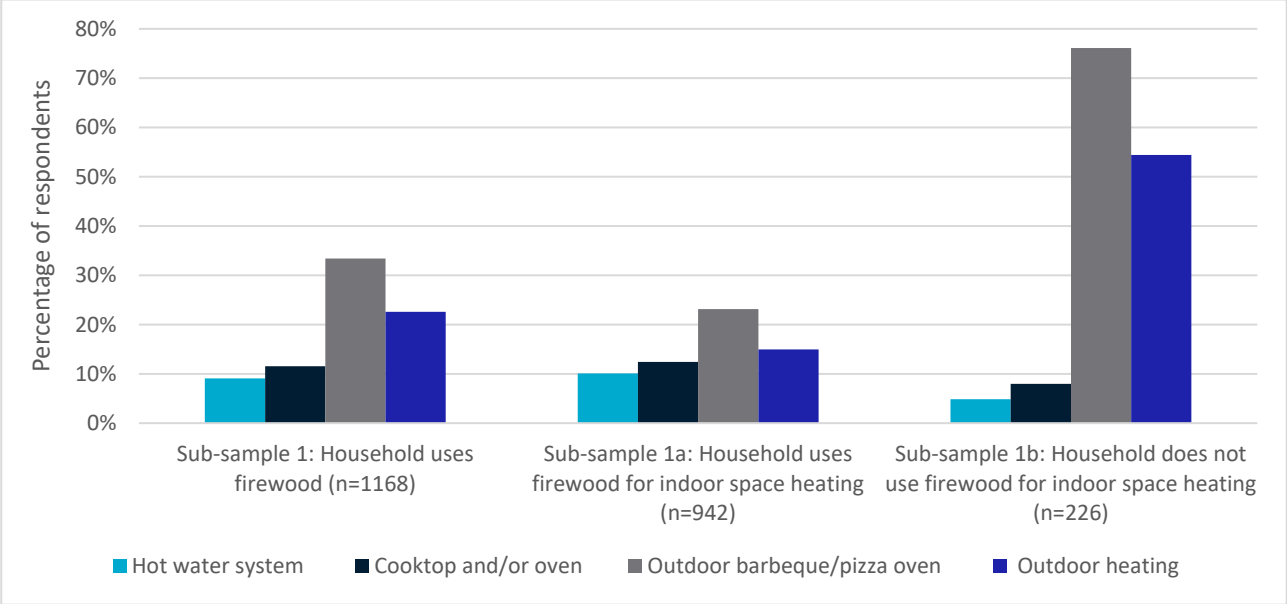


Figure 33. Use of firewood for purposes other than indoor space heating (for the sub-sample of firewood users)

Frequency and duration of using firewood

Among the sub-sample of survey respondents who use firewood for purposes other than indoor space heating, the self-reported frequency (i.e. average number of days per week) and duration (i.e. average number of hours per day) of using firewood for such purposes seems to vary depending on what the firewood is used for.

First, as shown in Figure 34, the average frequency of using firewood for hot water systems and cooktops/ovens was higher than the average frequency of using firewood for outdoor BBQs/pizza ovens and outdoor heating. Specifically, those who used firewood for hot water systems and/or cooktops/ovens reported using these wood-fired appliances for an average of 3.3 and 3.2 days per week, respectively. In contrast, those who used firewood for outdoor BBQs/pizza ovens and/or outdoor heating reported using these wood-fired appliances for an average of 2.2 days per week.

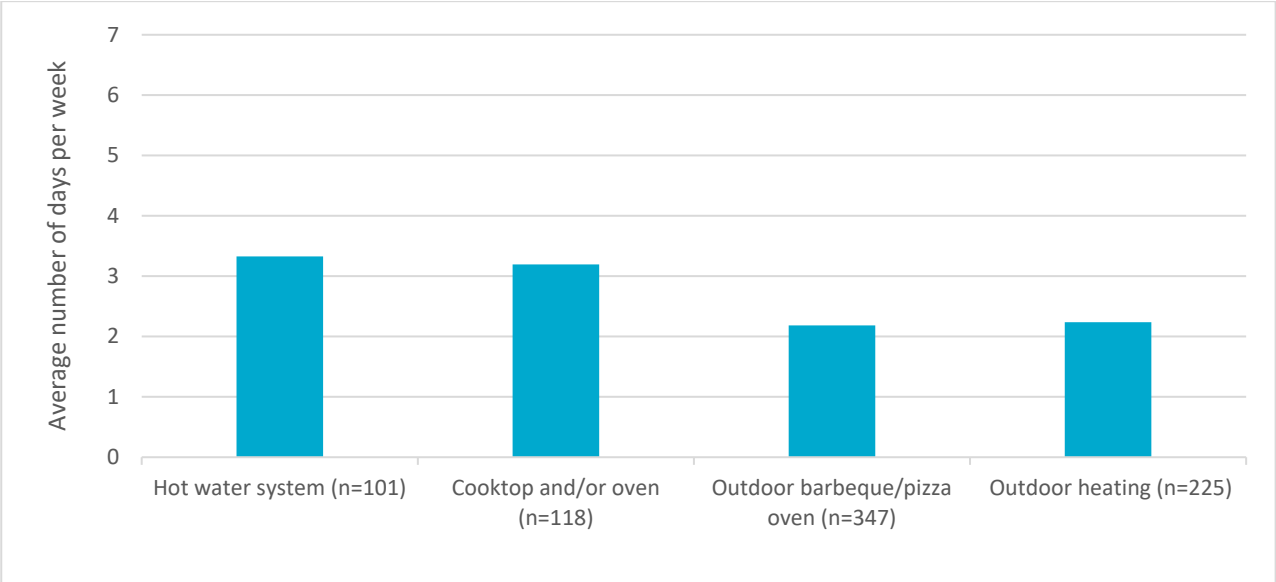


Figure 34. Average number of days per week firewood was used for purposes other than indoor space heating (for the sub-sample of firewood users who use firewood for purposes other than indoor space heating)

Second, as shown in Figure 35, the average duration of using firewood for hot water systems (4.1 hours a day) and cooktops/ovens (4.8 hours a day) was higher than the average duration of using firewood for outdoor BBQs/pizza ovens (3.0 hours a day) or outdoor heating (3.8 hours a day).

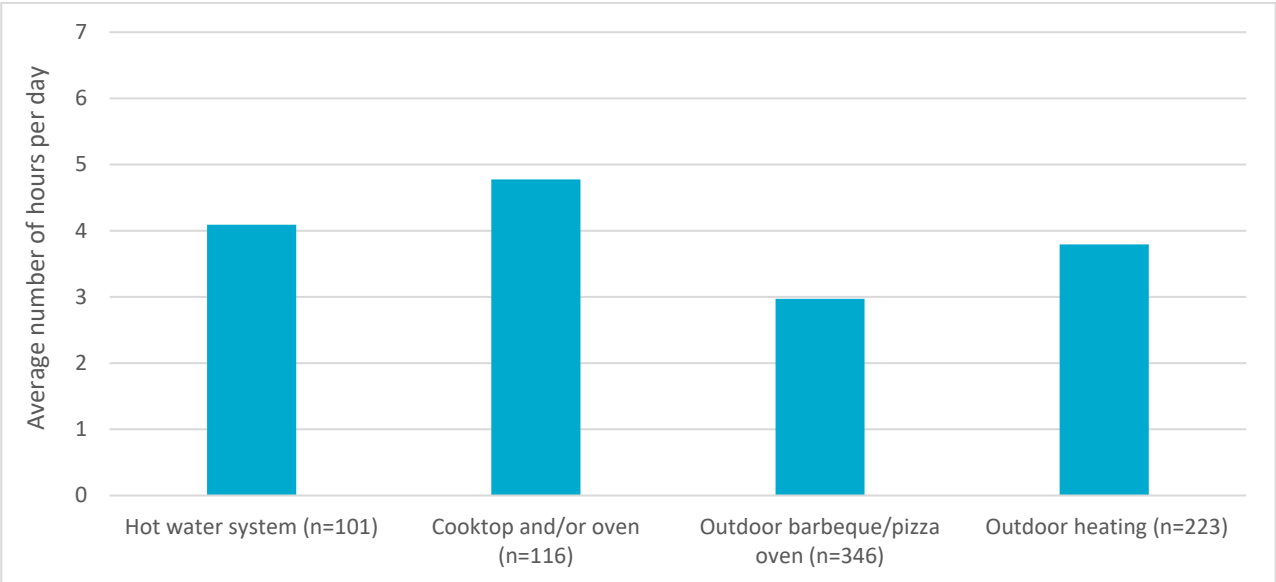


Figure 35. Average number of hours per day firewood was used for purposes other than indoor space heating (for the sub-sample of firewood users who use firewood for purposes other than indoor space heating)

3.6 Amount of firewood consumed

As the final step of the preliminary analyses, descriptive results were compiled for the amount of firewood consumed by households, as self-reported by respondents themselves in the survey. When interpreting these findings, it is important to note that unlike other residential energy sources such as electricity and mains gas, firewood consumption is not routinely measured or monitored – at least not using tools or methods akin to conventional energy meters. In turn, it is difficult to obtain objective, reliable and standardised measures of residential firewood use.

When surveying households, one feasible way to collect information on firewood consumption is to directly ask people about how much firewood they have used in a given timeframe. In turn, both surveys conducted as part of the current research included an open-ended question that served as the primary method for estimating firewood consumption. As shown below, the sub-sample of respondents who reported using wood as an energy source (i.e. 'firewood users') were asked for an estimate of the total amount of firewood consumed by their household in the past 12 months. The specific instructions and question wording used in the survey were as follows:

> *The next question asks about the total amount of wood used by your household's wood-fired appliance(s) in the past 12 months. Please count all types of wood used for energy/fuel, regardless of the source (e.g. purchased, self-collected or received for free). The quantity of wood used by your household can be measured in several ways – for instance by weight (e.g. kilograms or tonnes), volume (e.g. cubic metres), or lot (e.g. small, medium or large trailer/truck loads). For the next question, please answer in terms of whatever metric allows you to most accurately estimate the total amount of wood used for your household's wood-fired appliances in the past year. Please tap 'NEXT' to continue.*
>
> *Thinking about the past 12 months, approximately how much wood did your household use in total? In your response, please give both the amount and the unit of measurement, e.g. "1 tonne", "1 cubic metre", "1 standard-sized (6 x 4 foot) trailer load", etc.*

When answering this open-ended question, survey respondents were instructed to respond using whatever metric they desired (e.g. trailer loads, tonnes, cubic meters). To ensure consistency and comparability of responses across the sample, answers to this question were converted to a standard metric of weight (in tonnes) using some guiding principles. Specifically, if a respondent answered in terms of volume (e.g. cubic meters), this was converted to tonnes by considering 1 cubic meter of firewood as being equivalent to 0.5 tonnes[11]. If an answer was provided in terms of ute/trailer loads, this was first converted to cubic meters before converting to tonnes. In such cases, if the respondent failed to specify a trailer size, it was treated as a standard 6 x 4-foot trailer. Table 3 summarises the ute/trailer sizes provided by respondents in the survey, alongside the conversion used to estimated volume (i.e. cubic meters) and weight (i.e. tonnes) for each size.

[11] Based on previous research (Driscoll et al., 2000; Rothe et al., 2015; Todd, 2008), 1 cubic meter of firewood was considered equivalent to 0.5 tonnes of firewood.

Table 4. Trailers sizes provided by survey respondents and conversion to cubic meters and tonnes

Trailers sizes (in feet)	Estimated volume (in cubic meters)	Weight (in tonnes)
4x4	0.45	0.22
6x4	0.6	0.33
6x8	1.34	0.67
7x4	0.78	0.39
7x5	0.98	0.49
8x4	0.89	0.45
8x5	1.11	0.56
8x6 (caged)	5.35	2.68
12x6	2.01	1.00

In terms of these estimates and conversions, it is important to note that the survey data used for this research is inherently subject to some degree of human error and imprecision. Collecting self-reported data on the amount of firewood used retrospectively, over an extended timeframe (e.g. 12-month period) and in a range of metrics (e.g. trailer loads, cubic meters, tonnes) is subject to respondents' recollection and estimation capacity. In turn, the data should be treated with due caution and interpreted as a best estimate only.

With this caveat in mind, results are presented below for the amount of firewood consumed by households over the past 12 months, as self-reported by survey respondents. Among the sub-sample of firewood users, 86% (n=1,008) provided an estimate of firewood consumption over the previous year. As shown in Figure 36, among this group, about two-thirds (65%) reported using between 0.5 and 5.0 tonnes of firewood in the past 12 months. Just under one-quarter (23%) reported using less than half a tonne, with the remaining respondents (12%) reporting that they used 5.0 tonnes or more.

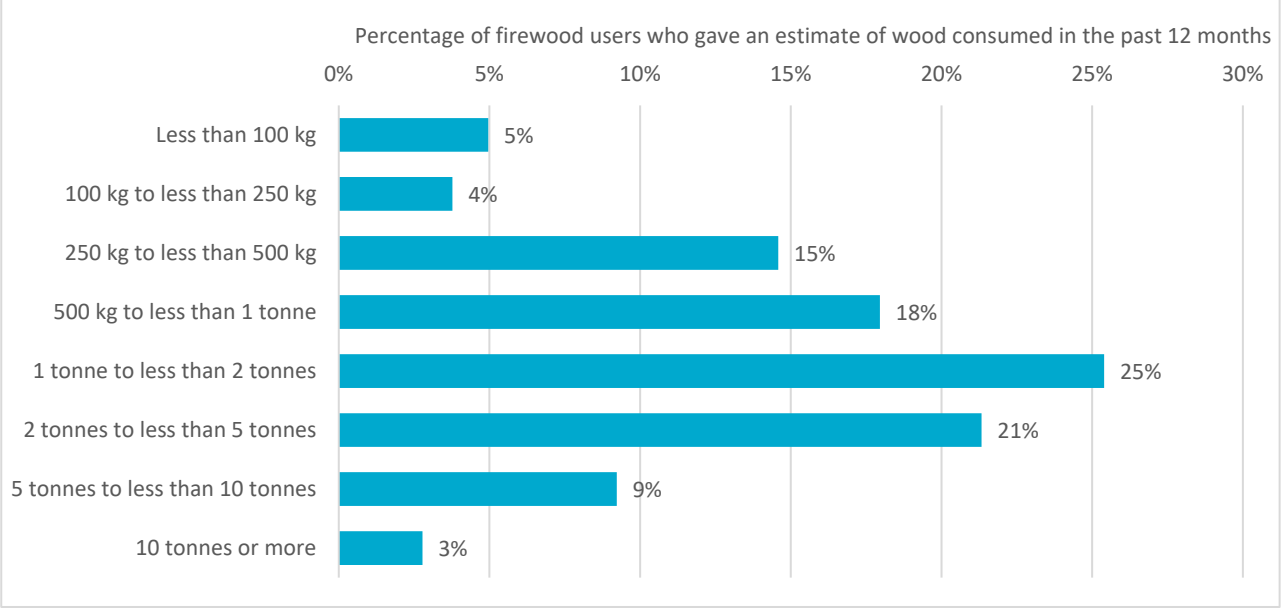


Figure 36. Amount of firewood consumed in the past 12 months, as self-reported by the sub-sample of firewood users (n=1,008)

Perhaps unsurprisingly, self-reported estimates for the total amount of firewood consumed by households varied across states and territories. As shown in Figure 37, the amounts estimated by respondents living in Tasmania (4.5 tonnes), Victoria (2.6 tonnes) and South Australia (2.3 tonnes) were higher on average than that of the total sample (2.1 tonnes). Conversely, those living in areas that typically experience warmer temperatures, such as Queensland and the Northern Territory, reported lower than average levels of firewood consumption (0.9 and 1.3 tonnes, respectively).

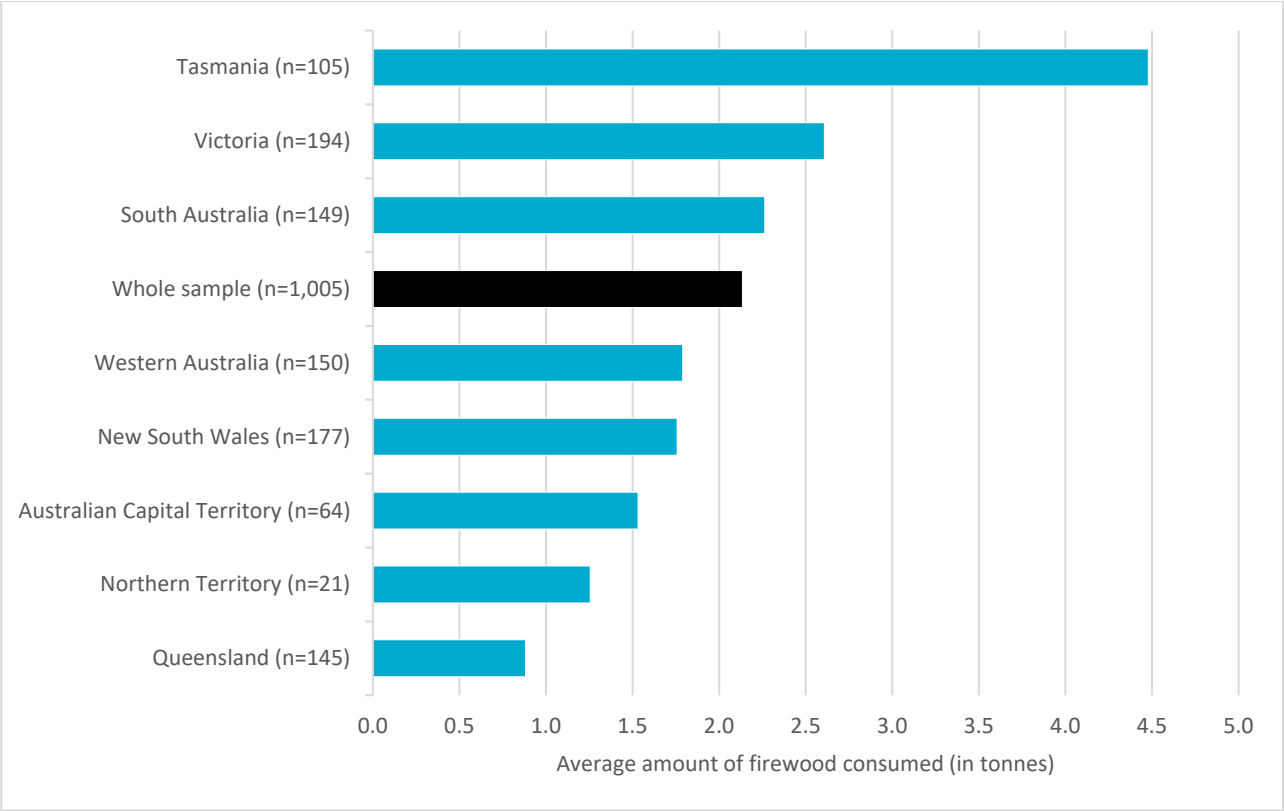


Figure 37. Average amount of firewood consumed in the past 12 months by households in each state and territory

Figure 38 presents a more detailed analysis of the average amount of firewood consumed by households in the 12 months preceding the survey, with results segmented by Greater Capital City Statistical Areas (GCCSA). Separate wood consumption estimates are presented for households that reported using vs. not using wood as their main energy source for indoor space heating. Due to small sample sizes in the Northern Territory, the average self-reported consumption of wood is not presented for GCCSA regions but instead for the entire territory. Even so, due caution must be exercised when interpreting the results for this territory as the number of survey respondents is very small (e.g. the average firewood consumption for those who use firewood as their main type of indoor space heating is based on data from only five survey respondents).

As shown in Figure 38, survey respondents who used firewood as their main source of indoor space heating reported consuming much higher amounts of firewood on average than those who did not use firewood as their main source of indoor space heating. Breaking down the analysis into GCCSA regions also shows how the amount of firewood consumed by households varies between states and territories, as well as whether the household is located in a capital city vs. rest of state. For example, in states such as Tasmania, Victoria and New South Wales, survey respondents who were living outside of capital cities (i.e. in 'rest of state' areas) reported noticeably higher estimates of firewood consumption on average compared to those living in capital cities.

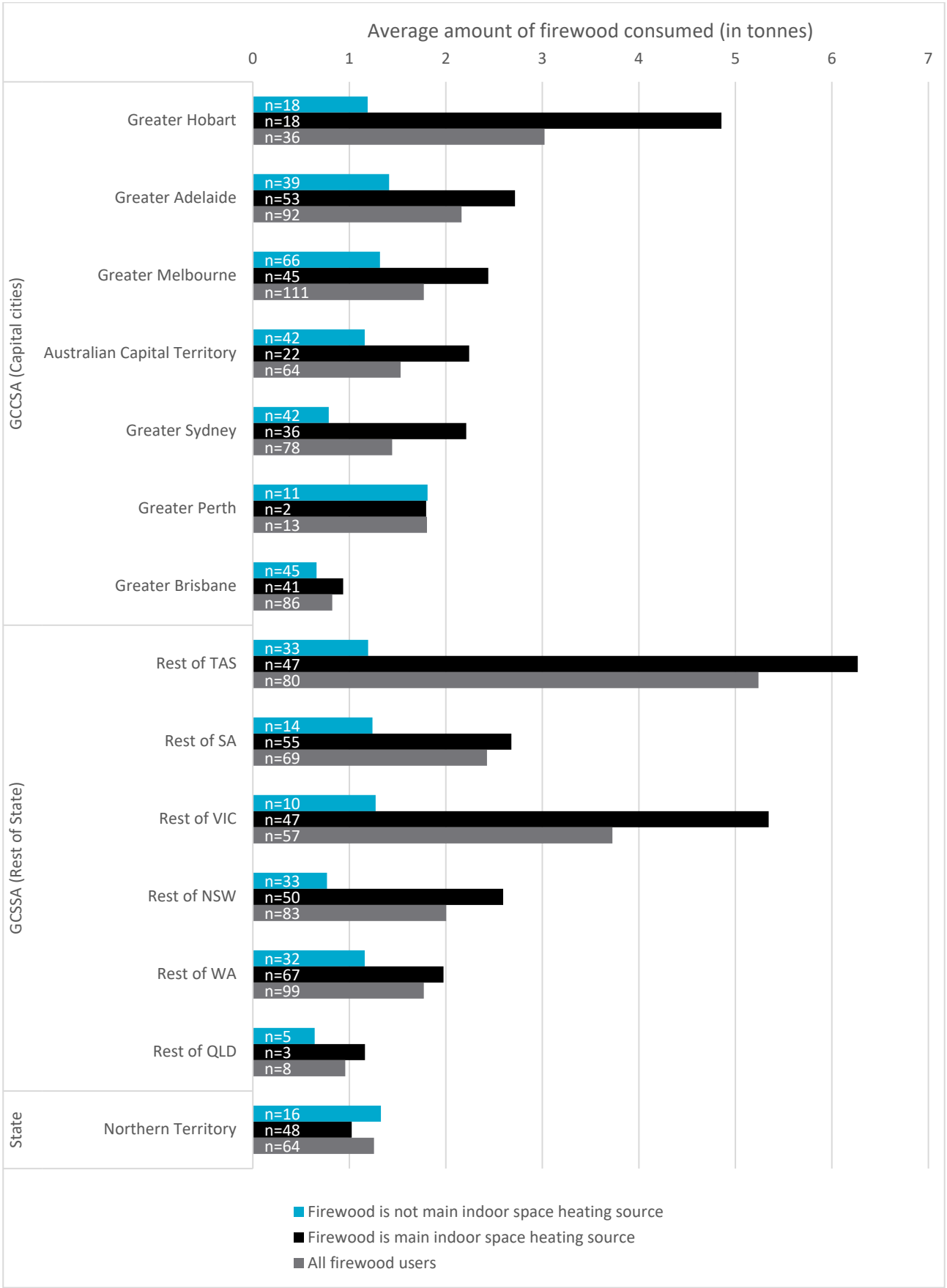


Figure 38. Average amount of firewood consumed (in tonnes) in the past 12 months, as self-reported by survey respondents who use wood as an energy source

4 Key predictors of firewood consumption

The previous section presented the results of preliminary analyses to explore whether differences exist in the demographic and dwelling characteristics of survey respondents who reported using vs. not using wood as an energy source at home. It also explored what types of domestic activities firewood is typically used for (e.g. heating, cooking, hot water) and the self-reported behaviour of firewood users (e.g. timing, frequency and duration of using wood). In this section, we extend on these preliminary findings by using regression analysis to examine what factors (when considered together) significantly contribute to explaining the amount of firewood consumed by households.

4.1 Previous research on the key predictors of firewood use

Previous research on the determinants of firewood consumption in Australia is limited. However, a number of overseas studies have been conducted in this area. Specifically, a brief review of the international peer-reviewed literature has identified a number of studies that have examined the key predictors of firewood consumption among households. For example:

- Azevedo et al. (2016) conducted a household energy survey to explore the drivers of residential wood consumption within a small city in Portugal. Results revealed that the use of wood was primarily explained by housing characteristics (e.g. building type, floor area and year of construction), alongside the age of the household head. Moreover, variability in the amount of wood consumed by households was found to be explained by factors such as housing type, year of construction, education level of the household head, and the burning device used by the residence.
- Arabatzis and Malesios (2011) conducted an econometric analysis of residential fuelwood consumption in Northern Greece and found that a mix of geographical factors (e.g. urban vs. rural location), socio-economic characteristics (e.g. household size, household income, fuelwood price), and more general environmental issues (e.g. environmental responsibility) were important for explaining differences in residential wood consumption for space heating and cooking.
- Couture et al. (2012) used an economic approach to explore household energy choices and fuelwood consumption in France, with results revealing that the choice of energy mix is dependent on the income and socio-economic characteristics of households. For example, higher income households were less likely to choose wood as their main energy source for heating, with the age and profession of the head of the household also having a significant impact on the probability of choosing fuelwood as the main energy source for heating. Dwelling characteristics (e.g. type, size, equipment) were also identified as important, with those living in free-standing houses and larger dwellings (e.g. more rooms) having larger probabilities of using firewood than those living in apartments and smaller dwellings. The authors also found that when wood was the main source of household energy, fuelwood consumption was price-sensitive.

- Lillemo and Halvorsen (2013) explored the determinants of firewood demand in Norwegian households and found that a mix of lifestyle factors, household and dwelling characteristics were important. Specifically, the price of firewood, living an urban lifestyle, education level, concerns over comfort, and the age of a household's main income earner were all found to have strong negative associations with firewood demand. Conversely, living in a detached house or farmhouse (vs. apartment) had a significant positive effect on firewood consumption, as did the number of years living in one's current residence.
- Lindroos (2011) has proposed that firewood consumption in Northern Sweden is a function of the household's need for heating (which depends on climate, building size, construction standard, insulation etc.), ownership of a firewood-based heating system, as well as access to firewood (which depends on population density and forest ownership).
- Song et al. (2012) examined the factors impacting household wood energy consumption in the United States and found that location (urban vs. rural) was a key determinant, as were dwelling and household characteristics. Specifically, greater urbanisation was negatively associated with wood consumption, while dwelling age and household size were positively associated, i.e. those living in rural areas, older homes, and larger households tended to consume more firewood than those in urban areas, newer homes and smaller households. Moreover, while wood consumption was mainly influenced by non-wood energy prices in rural areas, it was primarily affected by household size and income level in urban areas.

In light of these insights from the international peer-reviewed literature, there is strong evidence to indicate that a combination of geographical (e.g. location), household and dwelling factors may be important in explaining firewood consumption in the residential sector. However, because the vast body of this prior research stems from outside Australia, there are questions over the validity and generalisability of results to our national context. Further research is therefore needed in order to identify the primary determinants of wood consumption among Australian households.

4.2 Current research on the key predictors of firewood use

To address the aforementioned gap in empirical research, a hierarchical regression analysis was conducted to examine the key predictors of firewood consumption in our sample of Australian households. This type of regression allows us to investigate whether specific variables of interest (i.e. independent variables) explain a statistically significant amount of variation in firewood consumption (i.e. dependent variable), after accounting for all other variables. From a statistical perspective, this analysis involves entering variables into the model in pre-defined groups, which allows us to assess the relative contribution of each group of variables to the overall model. In our research, this approach has the benefit of allowing us to explore the contribution of geographical, demographic, dwelling and behavioural factors to explaining variability in firewood consumption.

As shown in Table 5, our analysis involved running three models:

- Model 1 included variables related to the survey respondent's geographical location, namely: state/territory of residence, climate zone, and whether or not the respondent lived in a state/territory capital city (mapped using ABS GCCSA categories).

- Model 2 included the same variables as Model 1, alongside selected demographic variables (e.g. household size and composition, tenure, household income) and dwelling features (e.g. dwelling type and age, mains gas connection, number of firewood appliances).
- Model 3 included the same variables as Model 2, alongside selected behavioural variables (e.g. whether firewood is the main type of indoor space heating used by the household, number of months per year firewood was used for indoor space heating, average number of days per week and number of hours per day firewood was used for indoor space heating in winter).

Model 1 explained only 6% of the variance in the amount of firewood consumed (as self-reported by survey respondents), whereas Model 2 explained 30% of the variance, and Model 3 explained 53% of the variance. These results indicate that when demographic, dwelling and behavioural variables are simultaneously included in the model, the variables that explain the most variance in firewood consumption are (a) state/territory of residence, (b) the number of firewood appliances in the home; and (c) behavioural variables (e.g. whether firewood is the main source of indoor space heating, and frequency and duration of using firewood for indoor space heating in winter).

Interestingly, these results also suggest that demographic and dwelling-related variables are less important in explaining variability in residential firewood consumption compared to geographic and behavioural variables. Indeed, none of the demographic or household-related variables that were added to Model 2 emerged as statistically significant. While a few dwelling-related variables (e.g. dwelling type, mains gas connection, number of wood-fired appliances) appeared to play a more important role, most of these variables became non-significant when behavioural variables were also included in Model 3. In this third model, the strongest predictors were geographical location (in terms of state/territory of residence, but not climate zone) and behavioural variables. While one dwelling-related factor (specifically, the number of wood-fired appliances) remained statistically significant, all other dwelling and demographic variables were non-significant.

Due to the large number of non-significant variables in Model 3, two more regressions were run:

- Model 4 involved removing non-significant variables from Model 3, then re-running the analysis using data from all survey respondents[12]. As shown in Table 6, Model 4 explained a reasonable proportion of variance in the self-reported firewood consumption of survey respondents – a similar amount to Model 3 (Adjusted $R^2 = 0.53$).
- Model 5 involved re-running Model 4, but only using data from the sub-sample of survey respondents who reported using firewood at home. As shown in Table 5, the amount of variance in firewood consumption explained by this model was lower than Model 4 but still significant (Adjusted $R^2 = 0.30$).

Overall, the results of these final two regressions demonstrate the value of measuring not only geographic and location-based factors in household surveys, but also behavioural variables. By doing so, the data collected through surveys is likely to explain more variability in the self-reported wood consumption of households across Australia.

[12] To determine whether the removal of non-significant variables was appropriate, a hierarchical regression analysis was conducted where Model 4 variables were introduced first, followed by the remaining (non-significant) variables included in Model 3. Results showed no significant difference between Models 3 and 4 in the amount of explained variance (R^2 difference = -0.002), $F(14, 3818) = 28.90$, $p = 1.000$).

Table 5. Hierarchical regressions models

VARIABLES INCLUDED IN REGRESSION	Model 1		Model 2		Model 3	
ACT	-0.76***	(0.09)	-0.51***	(0.10)	-0.43***	(0.08)
NSW	-0.20	(0.12)	-0.02	(0.13)	-0.29**	(0.10)
NT	0.26	(0.23)	0.18	(0.24)	-0.22	(0.19)
QLD	-0.11	(0.17)	-0.07	(0.17)	-0.42**	(0.14)
SA	0.05	(0.13)	0.16	(0.13)	-0.27*	(0.11)
VIC	-0.17	(0.12)	0.13	(0.12)	-0.19	(0.10)
WA	0.06	(0.14)	0.15	(0.14)	-0.38***	(0.11)
TAS (base)						
ABCB Climate Zone 1	-1.08***	(0.19)	-0.88***	(0.20)	-0.02	(0.16)
ABCB Climate Zone 2	-0.87***	(0.16)	-0.72***	(0.16)	-0.07	(0.13)
ABCB Climate Zone 3	-1.06***	(0.23)	-0.99***	(0.24)	-0.09	(0.19)
ABCB Climate Zone 4	-0.42**	(0.14)	-0.48***	(0.14)	-0.15	(0.11)
ABCB Climate Zone 5	-0.77***	(0.11)	-0.65***	(0.11)	-0.17	(0.09)
ABCB Climate Zone 6	-0.42***	(0.10)	-0.47***	(0.10)	-0.15	(0.08)
ABCB Climate Zone 7 (Base)						
Dwelling in capital city	-0.27***	(0.04)	-0.11*	(0.05)	0.01	(0.04)
Dwelling is a separate house			0.10*	(0.05)	-0.02	(0.04)
Dwelling built before 2000			0.08	(0.04)	-0.02	(0.03)
Owner-occupied dwelling			-0.00	(0.00)	-0.00	(0.00)
Number of occupants			0.09	(0.05)	-0.00	(0.04)
Household with children			0.01	(0.02)	0.01	(0.01)
Household income (mean)			0.03	(0.05)	0.02	(0.04)
Dwelling has mains gas connection			-0.30***	(0.04)	-0.01	(0.04)
Number of firewood appliances			0.76***	(0.02)	0.13***	(0.02)
Timing of using firewood for indoor space heating (months per year)					0.17***	(0.02)
Frequency of using firewood for indoor space heating in winter (days/week)					0.08***	(0.02)
Duration of using firewood for indoor space heating in winter (hours/days)					0.08***	(0.01)
Firewood is main source of indoor space heating					0.19*	(0.09)
_cons	1.27***	(0.07)	0.67***	(0.09)	0.47***	(0.08)
N	4641		3845		3845	
F	23.41		74.75		168.07	
r2	0.07		0.30		0.53	
r2_a	0.06		0.30		0.53	

Note: Standard errors in parentheses; * p<0.05; ** p<0.001; *** p<0.001;
R-Square Diff. Model 2 - Model 1 = 0.235; F (8,3822) =156.270; p< 0.001;
R-Square Diff. Model 3 - Model 2 = 0.233; F (4,3818) = 476.642; p< 0.001

Table 6. Regression models (reduced number of variables)

VARIABLES INCLUDED IN REGRESSION	MODEL 4 (ALL RESPONDENTS)		MODEL 5 (FIREWOOD USERS)	
ACT	-0.40***	(0.06)	-1.30***	(0.30)
NSW	-0.41***	(0.06)	-1.39***	(0.23)
NT	-0.27**	(0.10)	-0.81	(0.44)
QLD	-0.46***	(0.06)	-1.83***	(0.25)
SA	-0.42***	(0.06)	-1.39***	(0.24)
TAS (base)				
VIC	-0.30***	(0.06)	-0.86***	(0.22)
WA	-0.49***	(0.06)	-1.68***	(0.24)
Number of firewood appliances	0.10***	(0.02)	0.07	(0.05)
Timing of using firewood for indoor space heating (months per year)	0.16***	(0.02)	0.10*	(0.04)
Frequency of using firewood for indoor space heating in winter (days/week)	0.09***	(0.02)	0.08*	(0.04)
Duration of using firewood for indoor space heating in winter (hours/days)	0.08***	(0.00)	0.08***	(0.01)
Firewood is main source of indoor space heating	0.22**	(0.08)	0.38*	(0.17)
_cons	0.40***	(0.05)	1.51***	(0.24)
N	4634		979	
F	443.83		36.58	
r2	0.54		0.31	
r2_a	0.53		0.30	

Note: Standard errors in parentheses; * p<0.05; ** p<0.001; *** p<0.001

5 Estimating residential firewood consumption

The preceding analyses presented in this report are important for identifying the key variables to consider when computing nationwide estimates of residential firewood consumption. In this section, we extend on the earlier findings by presenting the analytical method used to compute such estimates for each state and territory of Australia.

Method for estimating residential firewood consumption

Extending on the results presented earlier, a statistical approach has been developed to estimate the total amount of firewood consumed per state and territory across Australia. Below, we explain the methodology used in this analysis, with the results presented thereafter.

The main data sources used to calculate the residential firewood estimation were:

(1) CSIRO Energise survey data

(2) Online panel survey data

(3) ABS Census of Population and Housing, 2016 (https://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder)

(4) ABS.Stat Projected households, Australia, 2016 to 2041 (http://stat.data.abs.gov.au/)

As described below and illustrated in Figure 39, a seven-step process was followed in order to produce estimates of residential firewood consumption for each GCCSA region of Australia[13].

Step 1 involved selecting a set of survey variables that were also captured by the 2016 ABS Census, and which help explain whether or not households use firewood as an energy source at home. This included the following variables:

(1) ABS Greater Capital City Statistical Area (GCCSA) classification: the proportion of households that use firewood as an energy source significantly varies across geographical locations. In particular, firewood use depends on: (a) the state or territory of residence; and (b) whether the household is located in a capital city vs. rest of state/territory.

(2) Type of dwelling: the proportion of households that use firewood as an energy source varies depending on the type of dwelling (i.e. separate house vs. semi-detached dwelling vs. apartment/unit vs. other type of dwelling). However, the earlier descriptive analyses revealed no statistically significant differences between semi-detached dwellings and apartments/units and cautioned the reliability of the 'other type of dwelling' category due to the small number of respondents who reported living in such a dwelling type.

[13] Due to a small sample size, estimates for the Northern Territory were calculated at state/territory level only (rather than for each GCCSA region) and for all dwelling types combined. Thus, estimates for each dwelling type and GCCSA region within the Northern Territory are not presented.

Step 2 involved using data collected through the online panel survey to calculate the proportion of households that are firewood users and non-firewood users for each GCCSA and dwelling type. Only data from the online panel survey was used at this step because, as demonstrated by the results in Section 2.2, the sample for the online panel survey tended to be more representative of the broader Australian population (i.e. more aligned with ABS 2016 Census data) than the CSIRO Energise survey for the variable of dwelling type – one of the key variables used in the estimation analysis. More specifically, as discussed in Section 3.1, the proportion of households that use firewood as an energy source appears to vary depending on the type of dwelling, i.e. those living in separate houses are more likely to use firewood than those living in other dwelling types, such as units/apartments and semi-detached dwellings. Therefore, drawing on data from a sample of respondents that more closely aligns with ABS Census data in terms of dwelling type is expected to yield more accurate estimates for the proportion of households that consume firewood.

In addition, results presented earlier in this report also indicate that when firewood was the main source of indoor space heating used by the household, respondents tended to report consuming greater amounts of firewood. In turn, **Step 3** involved using data from the online panel survey to determine for each GCCSA and dwelling type what proportion of households do vs. do not use firewood as their main source of indoor space heating. Again, data from the online panel survey was used (rather than CSIRO Energise survey data) due to better sample representativeness for the dwelling type variable.

Step 4 of the analysis involved downloading data from ABS Table Builder on the number of private dwellings within each combination of GCCSA region and dwelling type. As the data derived from ABS Table Builder is based on 2016 ABS Census data, it was important to estimate the number of dwellings for each GCCSA region in 2019. Therefore, **Step 5** involved using data from the ABS.Stat website that provides the projected number of households in Australia from 2016 to 2041 to estimate number of dwellings in each GCCSA region in 2019[14].

As outlined earlier in Section 3.6, the average amount of wood consumed per year (as estimated by survey respondents) appears to vary depending on a range of factors, such as the household's GCCSA region and whether firewood is the main source of indoor space heating used by the household. In turn, **Step 6** involved using the combined survey dataset (i.e. both the CSIRO Energise survey and online panel survey) to calculate the average amount of firewood consumed (in tonnes) for each GCCSA for: (1) households that use firewood, but firewood is not the main source of indoor heating; and (2) households that use firewood and firewood is the main source of indoor heating. To maximise the amount of data available for analysis, data from the combined survey sample was used at this step[15]. No distinction was made between dwellings types, as this variable does not appear to affect *amount* of firewood consumed by households in our sample.

[14] When using ABS.Stat to estimate the number of dwellings in each GCCSA region for 2019, it was not possible to take into account dwelling type (e.g. separate house, semi-detached, unit/apartment) because the projected numbers available are for the total number of households only. We acknowledge that in some GCCSA regions, growth in the number of dwellings might vary by dwelling type. For example, it is possible that in some capital cities the growth in dwelling numbers could be higher for apartments/units (where households tend to use less firewood) than for separate houses. In addition, as presented in Section 3, households living in newer dwellings tend to use less firewood, so the proportion of households that consume firewood may also vary over time as new dwellings are constructed.

[15] The regression analysis identified 22 responses as outliers. To improve the reliability of the estimates, these outliers were removed in the Step 6 calculation when estimating the total amount of firewood consumed.

Finally, **Step 7** involved calculating an estimate for the total amount of firewood consumed within each GCCSA region. This involved several sub-steps, as described below.

- First, for each GCCSA region, we started by estimating the total amount of firewood consumed by households that use wood as their main source of indoor space heating. To derive this estimate, we followed these steps:
    - Initially, we estimated the total number of dwellings that use firewood as their main source of indoor space heating by multiplying (1) the proportion of households that use firewood by (2) the proportion of these firewood users that use wood as their main source of indoor space heating and (3) the number of dwellings for each combination of GCCSA and dwelling type according to the 2016 ABS Census data. To do this, we used the following formula:

        $$X_1 = a \times b_1 \times c \quad (1)$$

        where:

        X_1 *= Estimated number of households that use firewood as their main source of indoor space heating*

        a *= Proportion of households that use firewood as an energy source*

        b_1 *= Proportion of firewood users that use firewood as their main source of indoor space heating*

        c *= Number of dwellings from 2016 ABS Census for each combination of GCCSA and dwelling type*

    - Next, we estimated the total amount of firewood consumed by households that use wood as their main source of indoor space heating by multiplying (1) the estimated number of dwellings that use firewood as their main source of indoor space heating by (2) the average self-reported amount of firewood consumed in the past 12 months for households that use firewood as their main source of indoor space heating. To do this, we used the following formula:

        $$Y_1 = X_1 \times d_1 \quad (2)$$

        where:

        Y_1 *= Estimated amount of firewood consumed by households that use firewood as their main source of indoor space heating*

        X_1 *= Estimated number of dwellings that use firewood as their main source of indoor space heating*

        d_1 *= Average self-reported amount of firewood consumed by households that use firewood as their main source of indoor space heating*

- Second, we estimated the total amount of firewood consumed by households that *do not* use firewood as their main source of indoor space heating for each GCCSA region. To derive this estimate, we followed these steps:
    - Initially, we estimated the total number of dwellings that do not use firewood as their main source of indoor space heating by multiplying (1) the proportion of

households that use firewood by (2) the proportion of these firewood users that *do not* use wood as their main source of indoor space heating and (3) the number of dwellings for each combination of GCCSA and dwelling type according to the 2016 Census data. To do this, we used the following formula:

$$X_2 = a \times b_2 \times c \quad (3)$$

where:

X_2 *=Estimated number of households that do not use firewood as their main source of indoor space heating*

a *= Proportion of households that use firewood as an energy source*

b_2 *= Proportion of firewood users that do not use firewood as their main source of indoor space heating*

c *= Number of dwellings from 2016 ABS Census for each combination of GCCSA and dwelling type*

- Next, we estimated the total amount of firewood consumed by those who *do not* use firewood as their main source of indoor space heating by multiplying (1) the estimated number of dwellings that do not use firewood as their main source of indoor space heating by (2) the average self-reported amount of firewood consumed in the past 12 months for households that *do not* use firewood as their main source of indoor space heating. To do this, we used the following formula:

$$Y_2 = X_2 \times d_2 \quad (4)$$

where:

Y_2 *= Estimated amount of firewood consumed by households that do not use firewood as their main source of indoor space heating*

X_2 *= Estimated number of dwellings that use firewood but do not use firewood as their main source of indoor space heating*

d_2 *= Average self-reported amount of firewood consumed by households that do not use firewood as their main source of indoor space heating*

- Third, to calculate the total amount of firewood consumed for each GCCSA region, we summed the estimated total firewood consumption for (1) households that use firewood as their main source of indoor space heating and (2) households that *do not* use firewood as their main source of indoor space heating. To do this, we used the following formula:

$$Y_{Total} = Y_1 + Y_2 \quad (5)$$

where:

Y_{Total} *= Estimated total amount of firewood consumed by households*

Y_1 *= Estimated amount of firewood consumed by households that use firewood as their main source of indoor space heating*

Y_2 *= Estimated amount of firewood consumed by households that do not use firewood as their main source of indoor space heating*

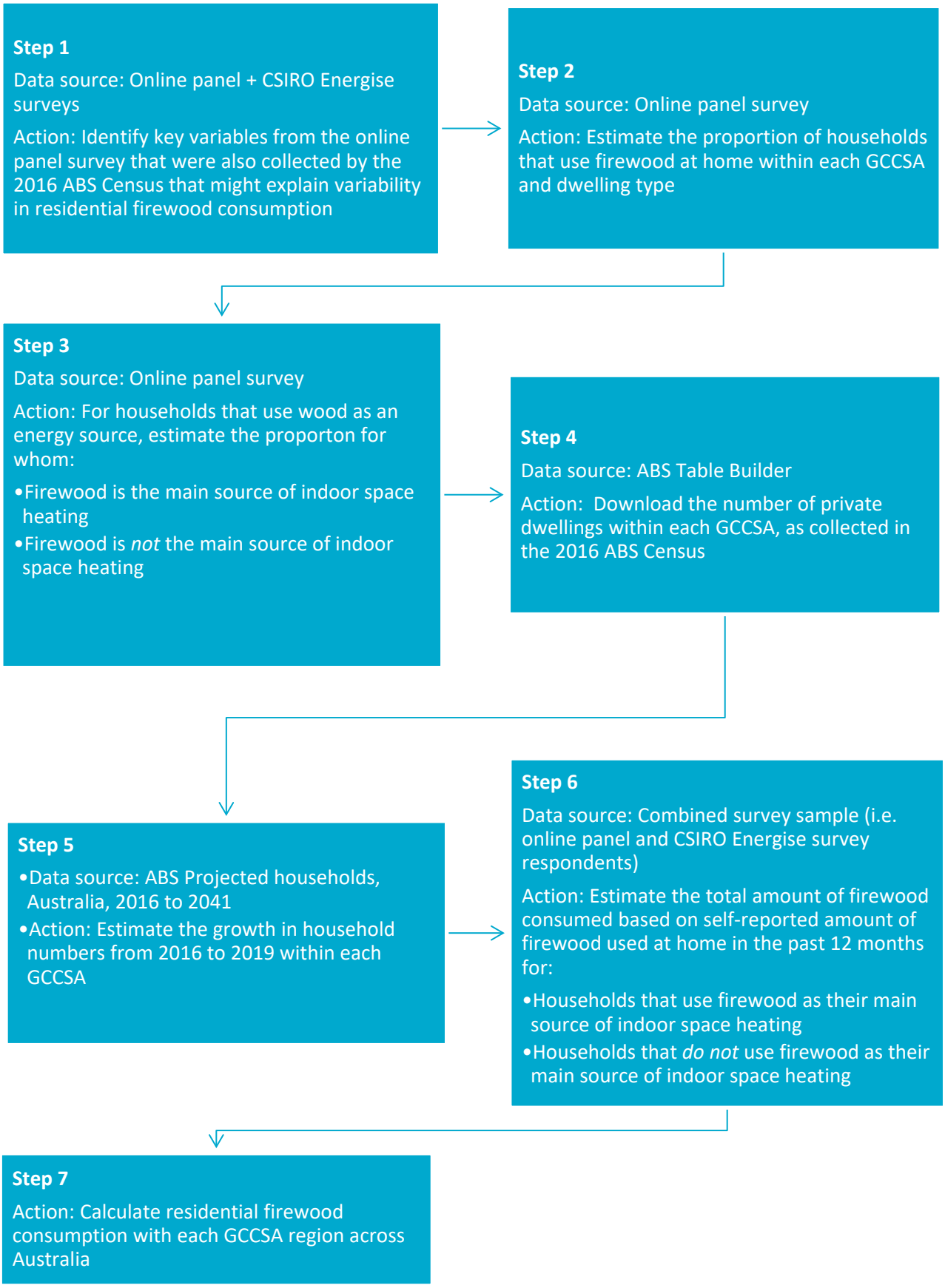


Figure 39. Seven-step process used to estimate residential firewood consumption across Australia

Results for estimated residential firewood consumption

Below, we report the results of the analyses to estimate the amount of firewood consumed by Australian households annually, based on self-report data collected through two surveys in 2019.

Table 7 presents the results for each state and territory in the metric of million tonnes, so it can be easily compared to the residential firewood consumption estimates computed by CSIRO in 2018, as well as findings from previous research (e.g. see Driscoll, 2000).

Table 7. Estimated amount of residential firewood consumption (in million tonnes) across Australia and comparisons with prior research

STATE/TERRITORY	2019 CSIRO SURVEYS (MILLION TONNES)			2018 CSIRO SURVEY (MILLION TONNES)	DRISCOLL (2000)
	2016 DWELLING NUMBERS	2019 DWELLING NUMBERS (SERIES I)	2019 DWELLING NUMBERS (SERIES III)	2016 DWELLING NUMBERS	(MILLION TONNES)
ACT	0.04	0.05	0.05	0.03	0.05
SA	0.40	0.41	0.41	0.32	0.41
QLD	0.30	0.32	0.33	0.25	0.33
TAS	0.37	0.39	0.40	0.32	0.72
VIC	1.35	1.43	1.49	1.56	1.21
WA	0.43	0.45	0.45	0.36	0.57
NSW	1.05	1.10	1.13	1.18	1.42
NT	0.03	0.03	0.03	n/a	n/a
NSW and ACT	1.10	1.15	1.18	1.21	1.47
All of Australia	3.98	4.17	4.29	4.03	
All of Australia (except NT)	3.95	4.12	4.23	4.03	4.71

Note: ABS Stat presents three series of projections (Series I, II and III), which are formulated on the basis of demographic trends seen in past data. The projections are simply illustrations of the growth and change in population which would occur if certain assumptions about future levels of fertility, mortality, overseas migration and internal migration were to prevail over the projection period. Series I is based on lower assumptions and Series III is based on higher assumptions.

Table 8 presents the estimated amount of residential firewood consumption for each state and territory in the metric of petajoules, so it can be easily compared to estimates of fuel consumption from wood/woodwaste, as reported in the most recent Australian Energy Statistics, Table F, issued in September 2019[16].

[16] Data available for download at: https://www.energy.gov.au/publications/australian-energy-update-2019

Table 8. Estimated amount of residential firewood consumption (in petajoules) across Australia and comparisons with the Australian Energy Statistics, Table F

STATE/TERRITORY	ESTIMATED AMOUNT OF FIREWOOD CONSUMED (PJ)			AUSTRALIAN ENERGY STATS (PJ)	
	2016 DWELLING NUMBERS	2019 DWELLING NUMBERS (SERIES I)	2019 DWELLING NUMBERS (SERIES III)	2016-2017	2017-2018
ACT	0.73	0.77	0.80		
SA	6.46	6.62	6.71	5.3	5.3
QLD	4.90	5.16	5.32	3.9	3.8
TAS	6.05	6.29	6.41	4.5	4.6
VIC	21.80	23.23	24.16	15.1	14.8
WA	7.04	7.24	7.30	5.3	5.3
NSW	17.02	17.82	18.30		
NT	0.43	0.45	0.45	0.1	0.1
NSW and ACT	17.75	18.60	19.10	14.6	14.3
All of Australia	64.44	67.57	69.44	48.8	48.2

6 Longitudinal analysis of firewood consumption

In this section, we start to explore changes in self-reported firewood use over time by comparing data collected through the CSIRO Energise surveys over two time-points. Specifically, a comparison analysis has been conducted using the data received from respondents who completed both the 2018 and 2019 CSIRO Energise firewood surveys (n=647). Below, key findings are presented for a subset of questions from the two surveys. The full question-set for each survey is presented in the Appendix (2019 Survey 1: CSIRO Energise and 2018 Survey: CSIRO Energise).

6.1 Use of wood as an energy source

First, we examined the degree of (in)consistency over time in the self-reported use of wood as an energy source among those respondents who completed both of the CSIRO Energise surveys. As shown in Figure 40, the vast majority of survey respondents (94%) reported either using firewood in both 2018 or 2019 (25%), or not using firewood in both 2018 and 2019 (69%). Only 6% of survey respondents reporting using firewood in only one of the two surveys.

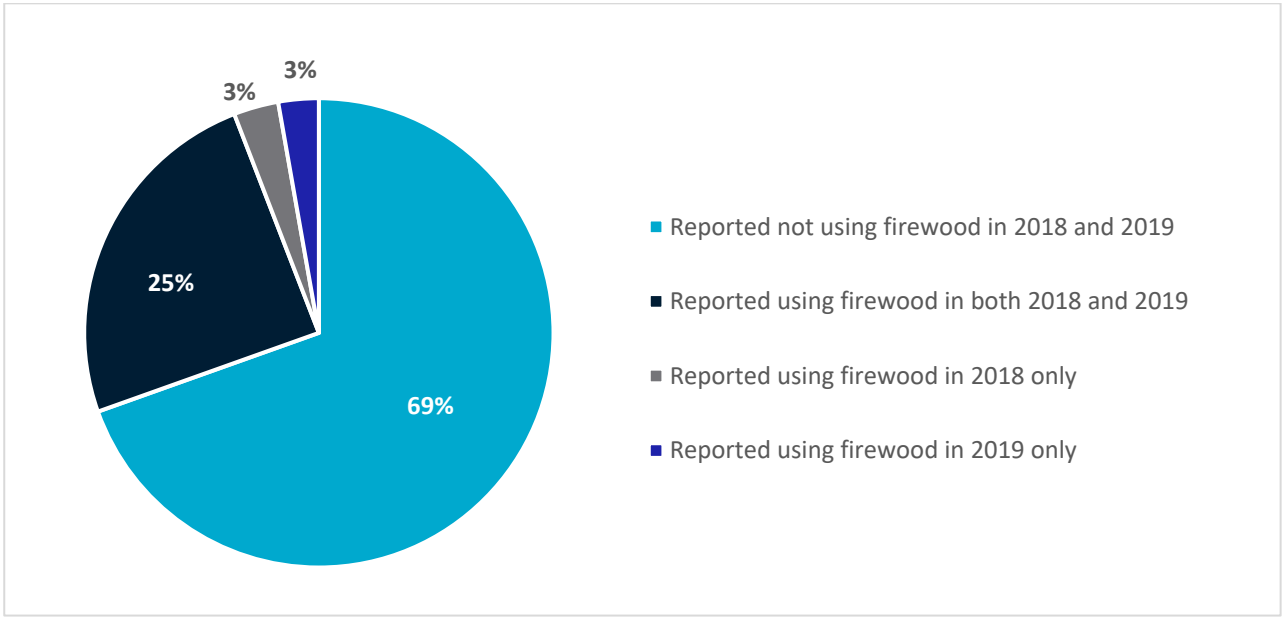


Figure 40. Survey respondents' self-reported use of firewood in the 2018 and 2019 surveys (n=647)

6.2 Wood-fired appliances

Next, we examined changes over time in the uptake and usage of wood-fired appliances, including recent and future purchases of such appliances. In this sub-section, the results on past and future purchases of wood-fired appliances pertain to the entire sample of respondents who completed both the 2018 and 2019 surveys, whereas the results on the number of wood-fired appliances currently used by households pertain only to those who reported using wood as an energy source.

Past purchases of wood-fired appliances

As shown in Figure 41, when asked about their recent purchases of wood-fired appliances, the majority of survey respondents (84%) gave consistent responses in 2018 and 2019. Overall, 81% of respondents indicated that they had not purchased a wood-fired appliance in the past 5 years in both the 2018 and 2019 surveys, and 3% of respondents indicated that they had purchased a wood-fired appliance in the past 5 years in both the 2018 and 2019 surveys. This finding is not surprising, as some types of wood-fire appliances can last decades.

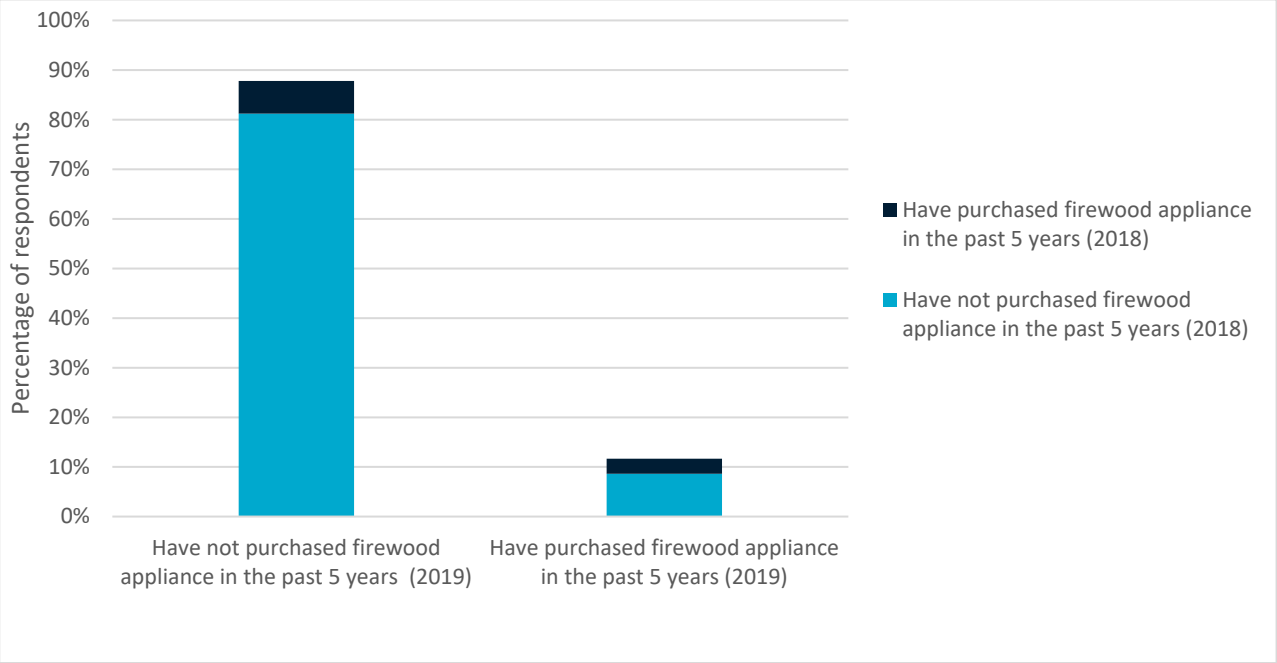
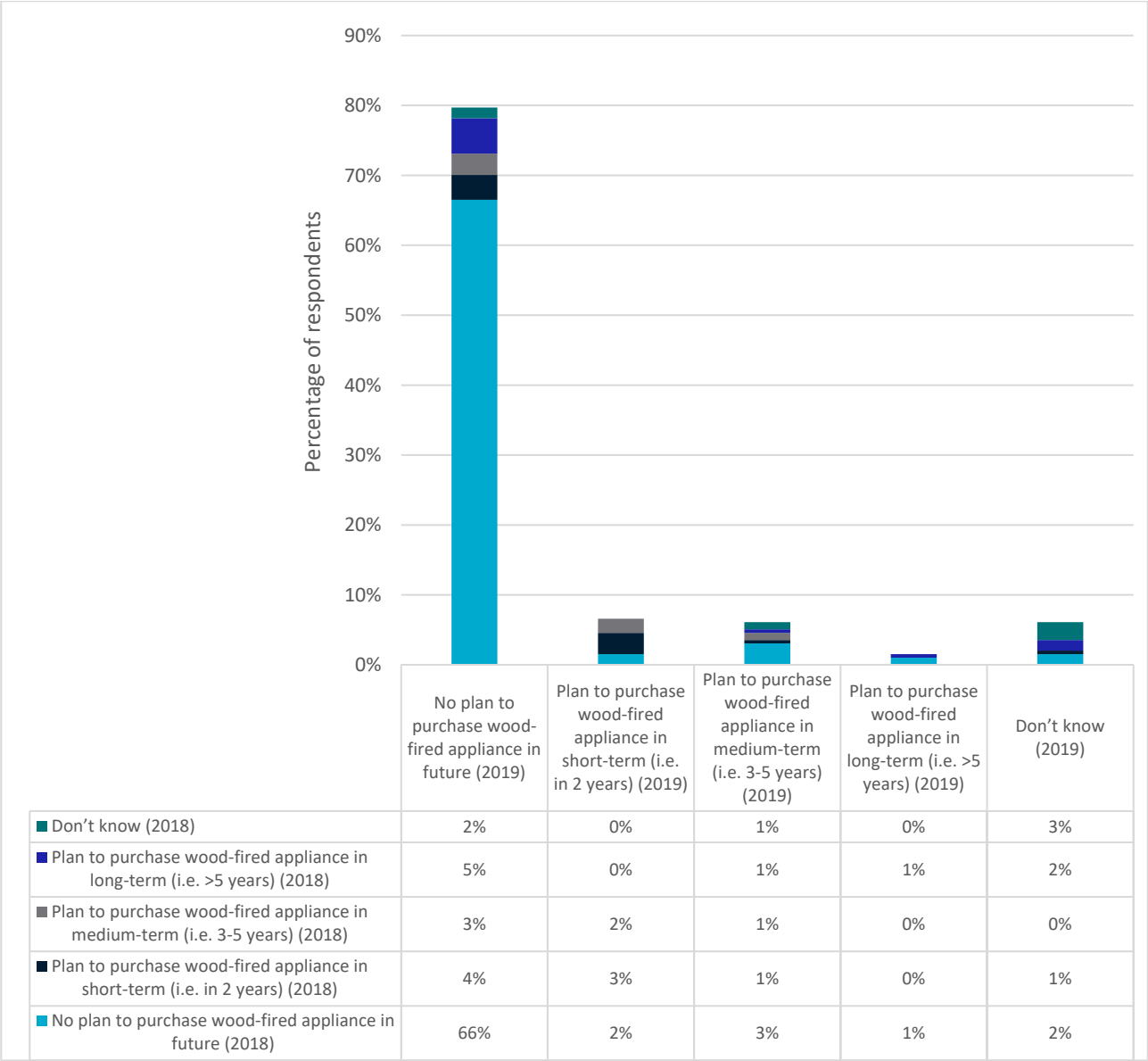


Figure 41. Recent purchases of wood-fired appliances: 2018 vs. 2019 CSIRO Energise surveys

Intention to purchase wood-fired appliances in the future

As shown in Figure 42, when asked about their plans to purchase wood-fired appliances in the future, most survey respondents (74%) gave consistent responses in 2018 and 2019. That is, they reported no change in intentions over time. More specifically, two-thirds of respondents (66%) expressed no intention to purchase a wood-fired appliance in both the 2018 and 2019 surveys. In addition, just under one-in-ten (9%) expressed an intention to purchase a wood-fired appliance sometime in the future (either in the short, medium or long-term) in both surveys.



	No plan to purchase wood-fired appliance in future (2019)	Plan to purchase wood-fired appliance in short-term (i.e. in 2 years) (2019)	Plan to purchase wood-fired appliance in medium-term (i.e. 3-5 years) (2019)	Plan to purchase wood-fired appliance in long-term (i.e. >5 years) (2019)	Don't know (2019)
Don't know (2018)	2%	0%	1%	0%	3%
Plan to purchase wood-fired appliance in long-term (i.e. >5 years) (2018)	5%	0%	1%	1%	2%
Plan to purchase wood-fired appliance in medium-term (i.e. 3-5 years) (2018)	3%	2%	1%	0%	0%
Plan to purchase wood-fired appliance in short-term (i.e. in 2 years) (2018)	4%	3%	1%	0%	1%
No plan to purchase wood-fired appliance in future (2018)	66%	2%	3%	1%	2%

Figure 42. Intentions to purchase wood-fired appliances in the future: 2018 vs. 2019 CSIRO Energise surveys

Number of firewood appliances currently used

Among the sub-sample of respondents who reported using firewood in both surveys (n=159), 80% reported using the same number of wood-fired appliances in both 2018 and 2019. Specifically, 77% of respondents reported using one wood-fired appliance in both surveys and 3% reported using two wood-fired appliances in both surveys. The remaining 20% gave inconsistent responses over time, suggesting that the number of wood-fired appliances changed between 2018 and 2019.

Among the sub-sample of respondents who reported using firewood in at least one of the surveys (n=197), most (65%) reported using the same number of wood-fired appliances in both 2018 and 2019. Specifically, 62% reported using one wood-fired appliance in both surveys and 3% reported using two wood-fired appliances in both surveys. The remainder (35%) gave inconsistent answers over time, suggesting that the number of wood-fired appliances changed between 2018 and 2019.

6.3 Firewood characteristics

We also explored changes over time in the methods used by households to source firewood, as well as the type(s) of wood they consume. Unless otherwise specified, the results presented in this sub-section pertain to the sub-sample of survey respondents who reported using firewood as an energy source; thus, those who reported not using firewood are excluded from the results.

Source of firewood

Figure 43 shows the methods of sourcing firewood as reported by respondents in the 2018 and 2019 surveys. Overall, there was reasonable consistency over time in the responses of firewood users who completed both surveys. Just under half (48%) of all firewood users reported self-collecting wood in both 2018 and 2019. Moreover, 18% of firewood users reported purchasing wood from a commercial supplier/shop in both surveys, 17% reported receiving wood for free in both surveys, and 10% reported purchasing wood from a private seller in both surveys.

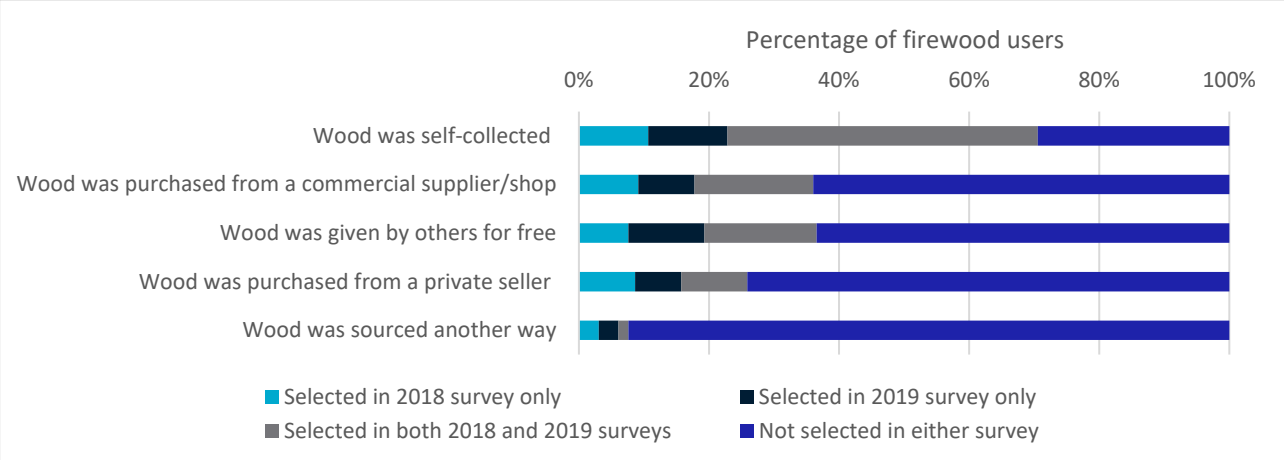


Figure 43. Methods of sourcing firewood: 2018 vs. 2019 CSIRO Energise surveys

Type of firewood used

Figure 44 shows the types of firewood used by survey respondents, as reported in the 2018 and 2019 surveys. Overall, about three-quarters of firewood users (75%) reporting using hardwood in both surveys, whereas 7% reporting using softwood in both surveys.

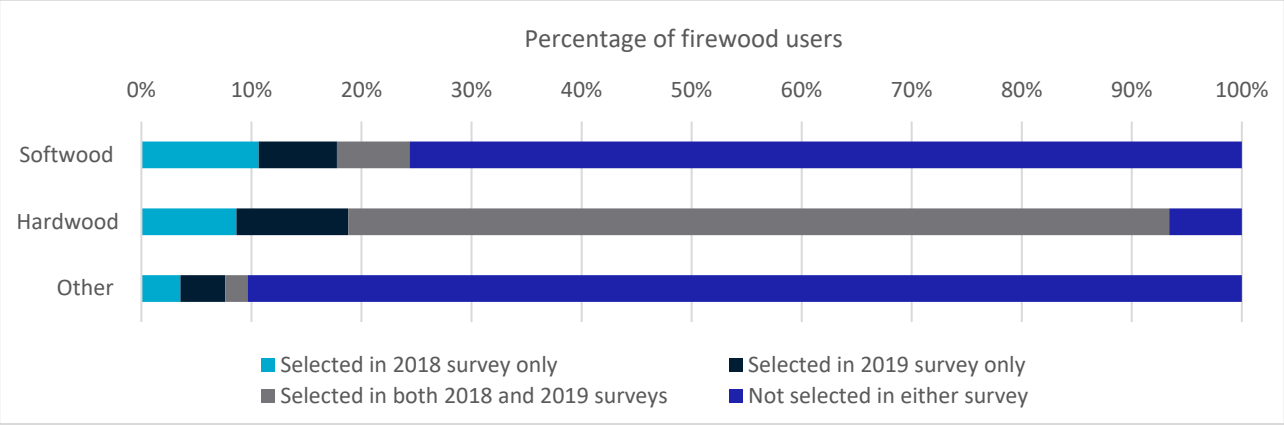


Figure 44. Type of firewood used by respondents: 2018 vs. 2019 CSIRO Energise surveys

Use of recycled wood/offcuts

Both surveys asked firewood users to indicate what proportion (if any) of the wood consumed by their household was recycled wood or offcuts. Figure 45 shows the use of recycled wood/offcuts by respondents in the 2018 and 2019 surveys. Across both surveys, the usage of recycled wood or offcut was relatively low. About two-thirds of respondents in both 2018 (66%) and 2019 (65%) reporting that less than one quarter or none of the wood they used was recycled/offcuts. While there was some variation in the use of recycled wood/offcuts over time, 45% of firewood users reported consuming the same proportion of recycled wood/offcuts in both surveys.

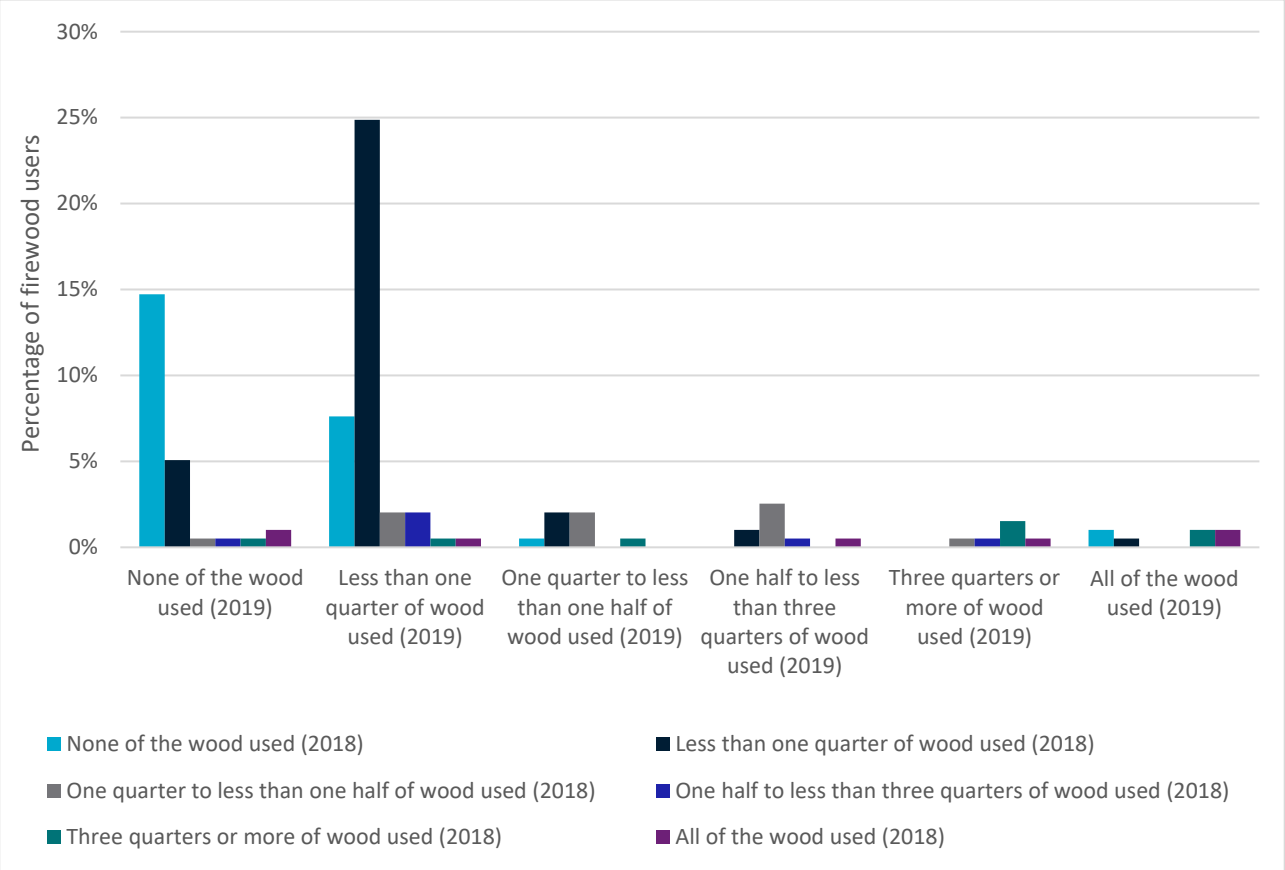


Figure 45. Use of recycled wood/offcuts: 2018 vs. 2019 CSIRO Energise surveys

6.4 Use of firewood for indoor space heating

Next, we examined changes over time in the use of firewood for indoor space heating, specifically by focusing on those survey respondents who reported using firewood in either the 2018 or 2019 surveys (n=197). As shown in Figure 46, around two-fifths (41%) of these respondents reported using firewood as their main source of indoor space heating in both 2018 and 2019, whereas just under half (48%) reported not using firewood as their main source of indoor space heating in both years. In turn, most respondents (89%) reported no change over time in terms of whether or not wood was their main source of indoor heating. The remaining respondents (11%) reported using firewood as their main source of heating in either 2018 (5%) or 2019 (6%), but not in both years.

Figure 46. Use of wood as the main source of indoor space heating among firewood users: 2018 vs. 2019 CSIRO Energise surveys

When comparing these results for the 2018 and 2019 surveys, it is important to note that although the survey question about wood heating was the same, the response options slightly varied:

- In 2018, the question was formatted as a simple dichotomous item. It asked: 'In the past 12 months, was wood heating (e.g. fireplace) the main type of heating used by your household?'. Respondents were then presented with two response options: 'Yes' and 'No'.
- In 2019, the question was formatted as a single-select checklist. It asked: 'In the past 12 months, was wood heating (e.g. fireplace) the main type of space heating used by your household?'. Respondents were then presented with five response options: 'Yes', 'No, electric heating was main type', 'No, gas heating was main type', 'No, other heating was main type (please specify)' and 'Prefer not to say'.

This slight variation in the response options used in 2018 and 2019 was due to a desire to gain more in-depth information on what energy sources (e.g. electricity, gas, other) were preferred by households when wood heating was not the main type of space heating used. That is, rather than simply knowing whether or not a household used firewood as their main source of heating, the 2019 survey sought to understand what alternative energy sources were favoured by households that did not report using wood heating as their main type of heating.

6.5 Frequency and duration of using firewood

Both surveys included questions about the frequency (i.e. days per week) and duration (i.e. hours per day) of using wood-fired appliances. When comparing results from the 2018 and 2019 surveys, however, it must be noted that the wording of these questions varied between the two surveys:

- In 2018, one of the questions asked: 'Thinking about the cooler months of this year (e.g. April to September 2018), on average, how many days per week did your household use one or more wood-fired appliances?'
- In 2019, one of the questions asked: 'Thinking about this winter, on average, how many days per week did your household use one or more wood-fire appliances for space heating?'

Therefore, the question in the 2019 survey specified a shorter timeframe (i.e. winter being June to August) and had a narrower focus by asking about the use of wood-fired appliances for indoor space heating specifically, rather than the use of wood-fired appliances more generally.

Figure 47 and Figure 48 show the self-report responses to these questions about the frequency (i.e. number of days per week) and duration (i.e. number of hours per day) of using wood-fired appliances, respectively. In both cases, a *t*-test revealed no statistically significant differences in the self-reported frequency or duration of using wood-fired appliances in 2018 and 2019.

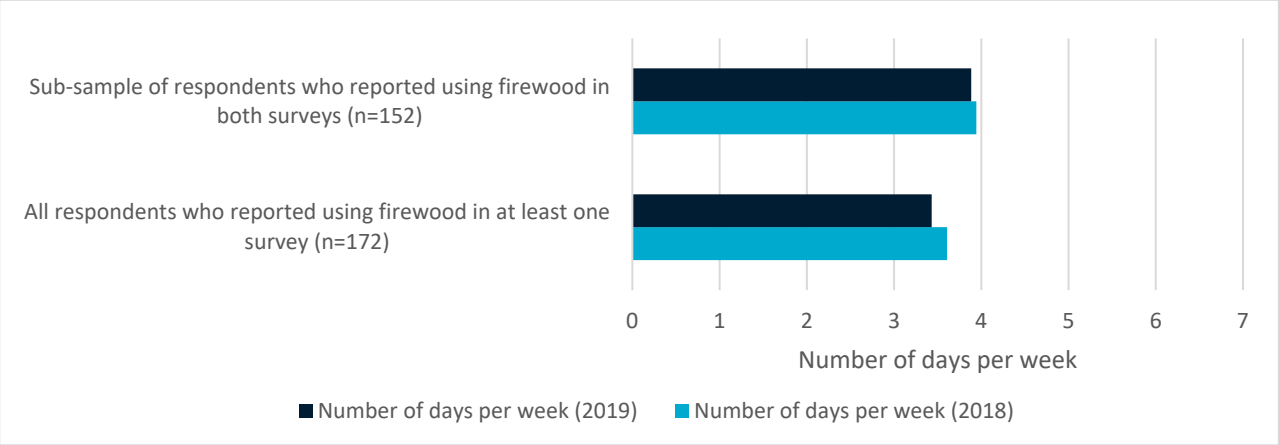


Figure 47. Self-reported frequency (days per week) of using firewood: 2018 vs. 2019 CSIRO Energise surveys

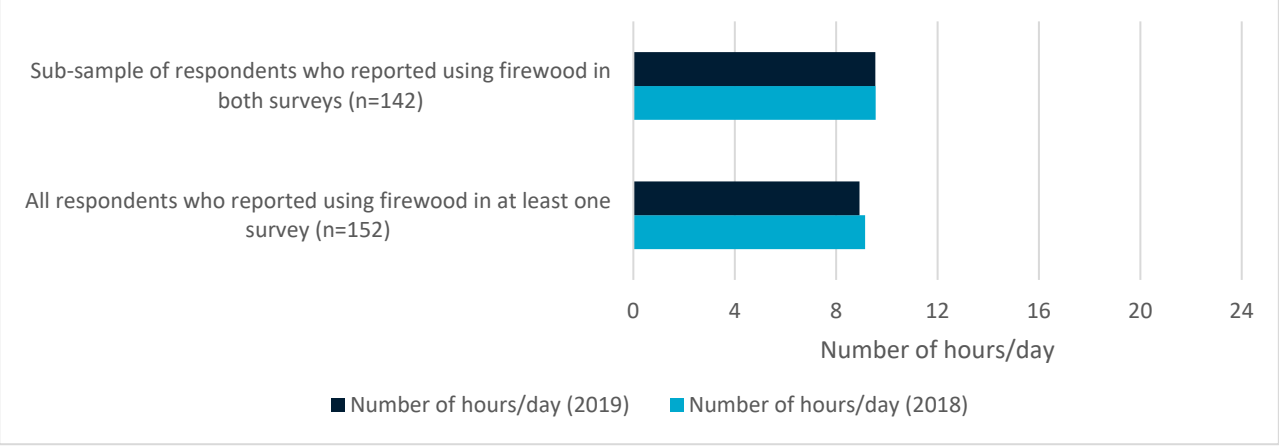


Figure 48. Self-reported duration (hours per day) of using firewood: 2018 vs. 2019 CSIRO Energise surveys

6.6 Amount of firewood consumed

Finally, to explore the degree of (in)consistency in self-reported wood consumption over time, we compared self-report data on the total amount of firewood used by respondents in the 2018 and 2019 surveys. As shown in Figure 49, when firewood users were asked to estimate how much wood they had consumed in the past 12 months, most respondents (54%) reported using similar amounts of firewood in both the 2018 and 2019 surveys. For example, 14% of firewood users reported using less than 1 tonne of firewood in both surveys, 18% reported using 1 tonne to less than 2 tonnes of firewood in both surveys, 17% reported using 2 tonnes to less than 5 tonnes of firewood in both surveys, and 6% reported using 5 tonnes or more of firewood in both surveys.

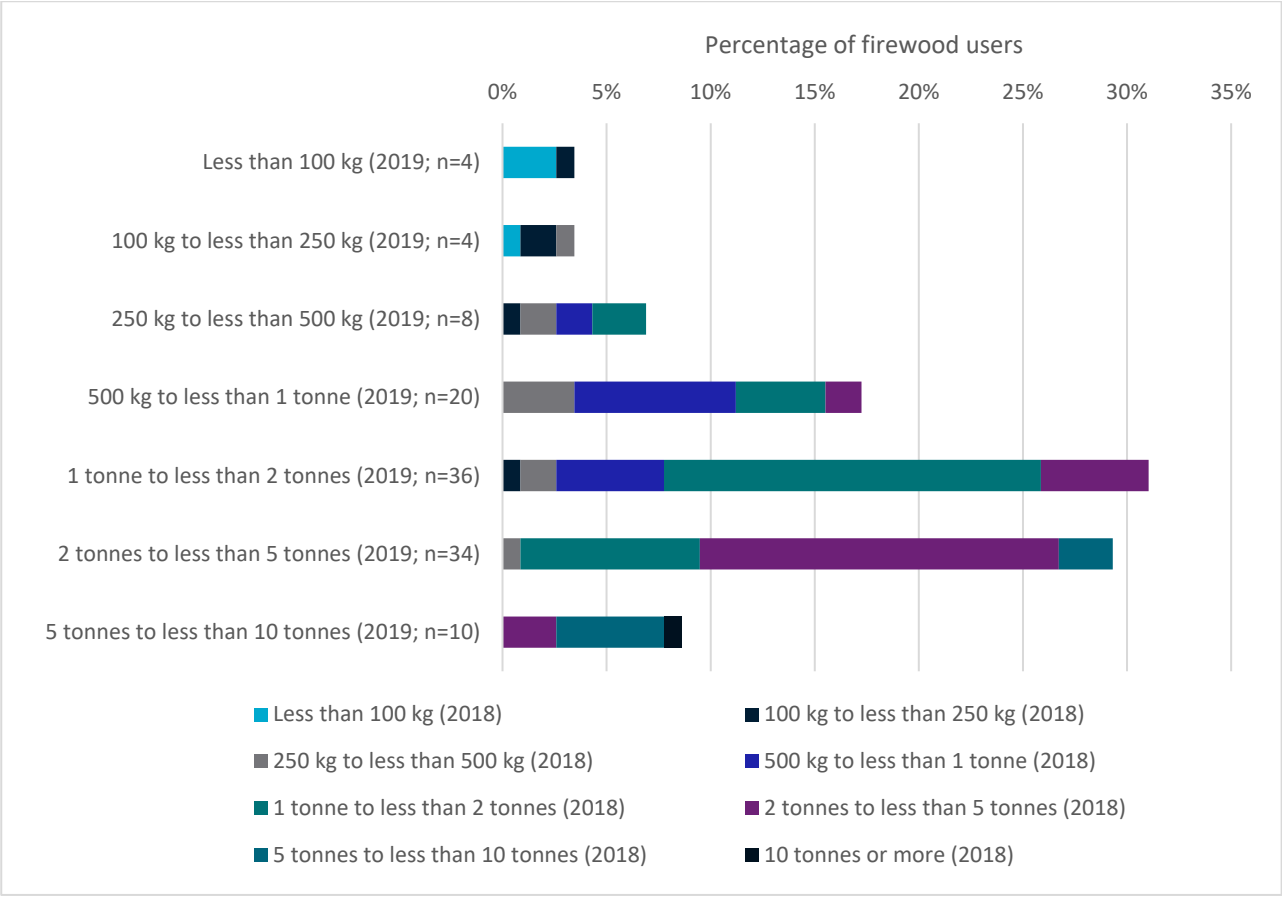


Figure 49. Amount of firewood consumed in the past 12 months: 2018 vs. 2019 CSIRO Energise surveys

Figure 50 also demonstrates little difference in the average self-reported amount of firewood consumed in 2018 and 2019 for the sub-sample of respondents who answered the survey question about the amount of firewood consumed in both years.

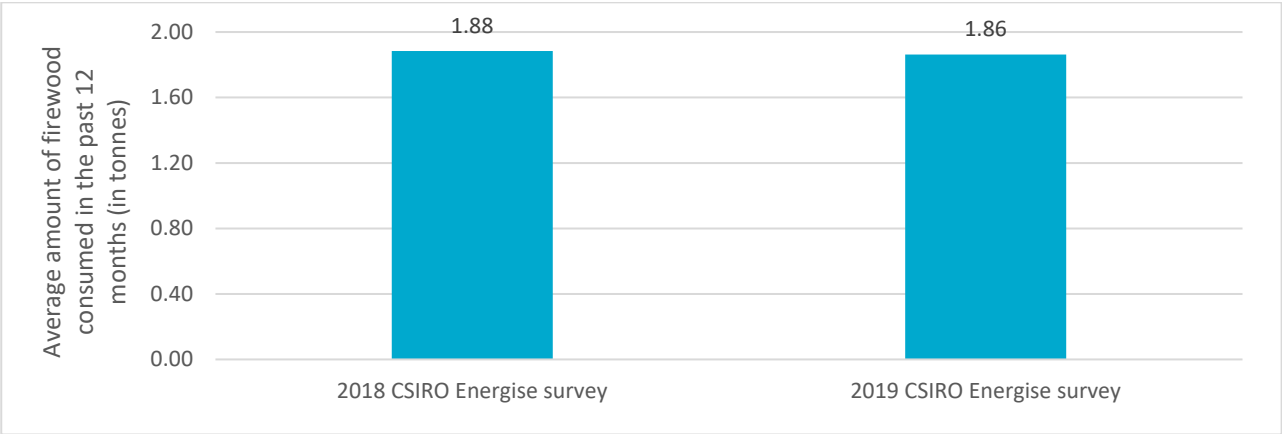


Figure 50. Average amount of firewood consumed in the past 12 months: 2018 vs. 2019 CSIRO Energise surveys

7 Discussion and Conclusion

The current research aimed to shed new light on the use of firewood by Australian households, and in parallel, develop a new method for estimating residential firewood consumption across the country. Extending on the CSIRO's earlier firewood research in 2018, two new surveys were conducted in 2019 to collect self-report data from a larger and more representative sample of Australian households, with a view towards identifying the key predictors of residential firewood use. A total of 4,844 residential energy consumers were surveyed across all states and territories, with about one-quarter reportedly using wood as an energy source at home.

The findings of these surveys show that the proportion of firewood users varies significantly due to a household's geographical location, demographics and dwelling characteristics. Furthermore, the results indicate that geographical location predicts not only the proportion of households that use wood as an energy source, but also the timing and frequency of firewood use, whether firewood is used for indoor space heating, and whether firewood is the main source of indoor space heating used by a household. Overall, these factors play a key role in explaining variability in the amount of firewood consumed by individual households, and across each Australian state and territory.

Drawing on this new survey data, statistical analyses have been conducted to generate updated estimates of residential firewood consumption for each Australian state and territory, with the results suitable for publication in the Australian Energy Statistics. In parallel, preliminary analyses of longitudinal data have been conducted to explore changes in self-reported firewood use over time, and in turn, to better understand how firewood consumption may vary within and between households from year-to-year.

7.1 Summary of key findings

Some of the key findings to emerge from this research include the following:

- Across the entire sample of Australian households that were surveyed, approximately one-quarter (24%) reported using wood as an energy source at home. The vast majority (89%) of respondents indicated that they had not purchased any wood-fired appliances in the past five years, with most (78%) also having no intention to buy or install such appliances in the future. Among those respondents that consume firewood as an energy source, the majority (89%) reported using only one or two wood-fired appliances at home.
- Geographical location is a key predictor of residential wood consumption, with survey data revealing that the proportion of firewood users varies significantly across states/territories. For example, compared to the national average, rates of firewood use were higher in Tasmania, Victoria, Western Australia, South Australia and lower in New South Wales, the Northern Territory, the Australian Capital Territory and Queensland. In general, the proportion of firewood users was also lower in capital cities than regional areas.
- Certain demographic and dwelling factors were also found to explain variability in wood consumption, with results revealing some noticeable differences between the

characteristics of firewood users and non-firewood users. For example, households that use wood as an energy source were more likely to be living in owner-occupied (vs. rented) dwellings, separate houses (vs. semi-detached dwellings and units/apartments) and homes constructed before 2000 (vs. since 2000). Firewood users were also more likely to be family households with children (vs. single or couple-only households), residences with three or more people (vs. one or two occupants only) and have annual household incomes of $78,000 or more (vs. lower annual incomes). Households that use bottle gas and/or solar electricity were also more likely to use firewood than households that use mains gas and/or electricity only.

- Among the sub-sample of survey respondents who reported using firewood as an energy source, the survey results also revealed geographical, demographic and dwelling-related differences in firewood consumption. For example, most firewood users reported using wood for indoor space heating; however, this proportion of households was higher than average in Tasmania, South Australia and Western Australia, but lower than average in Queensland, the Australian Capital Territory, and the Northern Territory.
- Among the sub-sample of respondents who used firewood for the specific purpose of space heating, the proportion who described wood as their main source of indoor space heating was lower among those in the Australian Capital Territory, Northern Territory and Victoria relative to other parts of the country. While using firewood as one's main type of indoor space heating varied across geographical locations, in almost all states/territories (except for the Australian Capital Territory), most respondents who used firewood for space heating also reported that firewood was their main source of indoor space heating.
- Using firewood as the main source of indoor space heating also varied across respondents depending on the age of the household's heating system. Specifically, the proportion of respondents who reported using firewood as their main source of indoor space heating was higher among those who bought/installed their wood-fired heating system after (vs. before) the year 2000.
- The timing, frequency and duration of wood consumption also differed across geographical locations. For example, respondents living in Tasmania reported using firewood for longer periods throughout the calendar year (e.g. mostly from April to October) than those living in Queensland (e.g. July was the only month when most people used firewood for indoor space heating). Those in Tasmania also tended to use firewood for more days per week and more hours per day compared to those living in Queensland and the Northern Territory.
- Firewood can be sourced in various ways; however, most respondents reported that they self-collect firewood from property/bush rather than buying it from a commercial supplier or shop, private seller, or obtaining it for free from others (e.g. family/friends). Self-collection of firewood was more common in remote or very remote areas of Australia, as well as outer regional Australia, compared to major cities and inner regional Australia.
- The vast majority (84%) of firewood users reported consuming hardwood timbers rather than softwoods. Moreover, the use of recycled wood/offcuts is relatively low, with most firewood users indicating that either none (23%) or less than one-quarter (32%) of all firewood used by their household was recycled/offcuts.

- Among the sub-sample of firewood users who provided an estimate of wood consumption over the previous year, about two-thirds (65%) reported using between 0.5 and 5 tonnes of firewood in the past 12 months. Just under one-quarter (23%) reported using less than half a tonne, with the remaining respondents (12%) reporting that they used 5 tonnes or more.
- Analyses to identify the key predictors of residential firewood consumption identified the following factors as explaining significant variance in the total amount of wood consumed by Australian households: geographical location, the number of wood-fired appliances used by the household, whether firewood is the main source of indoor space heating, the timing of firewood use (i.e. number of months per year firewood is used for indoor space heating), and the frequency and duration of firewood used for indoor space heating in winter (i.e. number of days per week and hours per day).

In light of these findings, it is perhaps unsurprising that the total amount of firewood consumed by households varied noticeably across different parts of the country. Nationwide, it was estimated that Australian households consume between 4.1 and 4.2 million tonnes of wood per year, which is equivalent to between 67.57 and 69.44 petajoules. However, there was substantial variability in wood consumption across individual states and territories. For example, total wood consumption was estimated to be highest in Victoria (1.43 to 1.49 million tonnes) and New South Wales (1.10 to 1.13 million tonnes), but lowest in the Northern Territory (0.03 million tonnes) and the Australian Capital Territory (0.05 million tonnes). It is hypothesised that these differences are not only due to different population sizes, but in some cases also variations in climatic and weather conditions.

When considering residential firewood consumption on a per household basis, differences were also observed across geographical locations. Results revealed that compared to the national average (2.1 tonnes), the amount of wood consumed per household per year was above-average in Tasmania (4.5 tonnes), Victoria (2.6 tonnes) and South Australia (2.3 tonnes), but below-average in Western Australia (1.8 tonnes), New South Wales (1.8 tonnes), the Australian Capital Territory (1.5 tonnes), the Northern Territory (1.3 tonnes) and Queensland (0.9 tonnes). Variability in the amount of firewood consumed between regions was also greater when wood was used for indoor space heating. This suggests that when wood is not used for indoor space heating, a household's geographical location is less important in explaining the amount of firewood consumed.

While the above estimates of total wood consumption are somewhat comparable to past research and official published statistics, there are some differences worth noting. For example, the largest difference compared to prior research (e.g. Driscoll, 2000) is for Tasmania (e.g. current estimates are lower than past research), while the largest difference compared to official published statistics (e.g. Australian Energy Statistics) is for Victoria (e.g. current estimates are higher than the official published statistics).

When interpreting these differences, it is important to note that these firewood consumption estimates were computed at different points in time and this may naturally influence the results (e.g. due to changes over time in population sizes, firewood use practices, climate, temperature and weather conditions, gas and/or electricity prices, etc.). In addition, the current study used different research methods, analytical approaches and participant samples compared to earlier research and other published statistics. These design-based features of the research may also explain (at least partly) why the firewood consumption estimates presented in this report differ

from other previous studies. Given these considerations, it would be valuable to conduct ongoing research in this area in order to replicate and validate the current findings. Future research that involves longitudinal or repeated-measures data collection, as well as validation studies to specifically evaluate the accuracy of self-report measures of firewood consumption, might also help to explain such differences between studies.

7.2 Limitations

There are some limitations of this research that must be considered when interpreting the key findings and drawing conclusions from the results presented in this report. In particular, it is important to take into account the potential drawbacks of relying on self-report survey data, constraints around sampling and sample representativeness, and the cross-sectional nature of data collection. Further detail on each of these limitations is outlined below.

Reliance on self-report data

First and foremost, it is important to note that the estimates of wood consumption presented in this report are based solely on self-report data collected through online and app-based surveys of Australian householders. Unlike other energy sources such as electricity and mains gas, firewood consumption is not routinely 'metered' or systematically measured/monitored in an objective manner by third-parties. Furthermore, given that people can source firewood in various ways (e.g. self-collected from bush/forests, purchasing from a private or commercial seller, receiving wood for free etc.) and use it for a range of domestic purposes (e.g. heating, cooking, hot water), it is difficult to obtain reliable estimates of firewood consumption using methods other than directly asking householders themselves.

Due to such challenges, the current research used self-report data collected via surveys in order to estimate the total amount of firewood consumed across Australian households. More specifically, participants were asked a single open-ended question about the amount of firewood used by their household in the preceding 12 months. As such, the resulting estimates of residential firewood consumption were based on the individual judgements of survey respondents, and in turn, may be prone to some error. Not only were respondents asked to estimate firewood use retrospectively and over a long timeframe (e.g. firewood use over the past year), they were also instructed to respond using whatever metric they preferred (e.g. trailer loads, cubic meters, tonnes). Thus, the estimates of firewood consumption collected through the survey are heavily dependent on the recollection and estimation capacity of respondents, and in turn, may be prone to some degree of human error and imprecision.

Relatedly, there could also be errors associated with the conversion between different metrics for firewood, as the relationship between weight and volume of wood may vary between different wood species. However, linked data on wood species and the quantity of firewood consumed by households was not collected as part of the surveys, thereby making it difficult to assess (and correct for) any conversation errors. In light of these considerations, the results presented herein

should be treated with due caution and interpreted as a best estimate only. All that said, other methods of estimating firewood consumption may also be vulnerable to errors and inaccuracy[17].

Sampling bias and sample representativeness

Another limitation of the current research is that the sample of survey respondents was not fully representative of the broader Australian population across all geographic, demographic and dwelling characteristics of interest. While concerted efforts were made to recruit a large sample that included a broad cross-section of the community, there was still some degree of sampling bias in the types of people who were invited to take part. For example, the surveys were purposely targeted at existing CSIRO Energise app users and online panel participants. As a result, the initial sampling frame used for the research was not entirely representative of the Australian population (i.e. not inclusive of each and every household across the country).

The methods used to initiate contact and collect data from participants may have also contributed to some degree of sampling bias. For example, the current research relied entirely on digital and online communication channels, which meant that households without access to mobile devices or the internet were excluded. Moreover, because the survey was entirely voluntary in nature, those who agreed to take part may systematically differ from those who refused to participate. Some degree of self-selection bias may have therefore impacted the research. Given these factors, it should be noted that the sample of households who took part in the survey may not fully reflect the wider Australian population on key geographical, demographic and dwelling characteristics.

Further, some limitations associated with the use of paid online panels should also be highlighted. As mentioned earlier, the types of individuals who sign-up to online panels (i.e. panellists) are not necessarily representative of the broader target population. Although some steps can be taken to improve sample representativeness (e.g. setting quotas for certain demographic factors in an effort to achieve good alignment between the sample characteristics and population parameters), online panels are naturally prone to some degree of bias in terms of self-selection and general willingness to respond to survey invitations. Put simply, the types of people who sign-up to online panels may differ systematically from the broader population (and in particular, from those who do not sign-up to online panels) and this may ultimately impact the external validity of results. In turn, while using paid panels has a number of practical benefits (e.g. more efficient and cost-effective recruitment), it is important to be cognisant of the potential implications for sample representativeness and generalisability of key findings to the broader population of interest.

Timing and duration of data collection

A final limitation of the current research pertains to the timing and duration of data collection. Because both of the wood consumption surveys were cross-sectional nature, self-report data was collected from participants over one period in time (e.g. a few months in the latter half of 2019). While the two surveys conducted in 2019 extended on CSIRO's earlier research in 2018, the data collected and subjected to analysis still only covers a relatively short timeframe (e.g. one to two

[17] For example, we found that most firewood consumed by Australian households is self-collected (55%), with a reasonable proportion also given for free by others (28%) or sourced from private sellers (31%). Because only a minority of households reported purchasing wood from a commercial supplier (33%), other methods of collecting data on wood use – such as surveying firewood suppliers directly – may also face validity and reliability issues. Generating estimates based on other criteria, such as the number or type of wood-fired appliances, may also be prone to inaccuracies by failing to take into account the behavioural aspects of appliance use (e.g. the timing, frequency and duration of using wood-fired appliances).

years). Thus, although preliminary steps have been taken to start exploring temporal variability in firewood consumption, further research over an extended timeframe is needed before strong conclusions can be drawn regarding changes in residential firewood consumption over time. In light of this, more longitudinal data collection would be a fruitful avenue for future research in order to fully explore how patterns of firewood use vary from year-to-year and beyond.

It is also worth noting that although the firewood surveys were cross-sectional in nature, some data collected prior to these surveys was also included in the data analyses for CSIRO Energise respondents. Specifically, for the CSIRO Energise sample, data on the background characteristics of respondents (e.g. demographic, dwelling and geographic factors) was sourced from earlier CSIRO Energise surveys, some of which were conducted months before the wood consumption survey. This difference in the timing of data collection is not necessarily ideal, as there is a possibility that a respondent's background characteristics may change over time. For example, a person might relocate dwellings or experience some other change in personal circumstances, such that their background characteristics at the time of the wood consumption survey differ from what they previously reported in the earlier CSIRO Energise surveys. Although it is difficult to measure and correct for this possibility, the impacts on data validity are judged to be minimal (i.e. we estimate there is little significant impact on the substantive results that are presented herein).

7.3 Directions for future research

The limitations described above highlight some fruitful avenues for future research, not only in terms of data collection but also statistical analysis. A summary of these potential opportunities for additional scientific research is provided below:

- Improve sample representativeness and the generalisability of results by collecting data from a larger sample of Australian households, and in particular, ensuring a good cross-section of the wider community is included (e.g. broad mix of demographics, dwelling types, geographic locations, climate zones etc.). This might involve using multiple methods and modes for recruitment, beyond online and digital channels – for example, postal, telephone or even face-to-face surveying (in the case of very hard-to-reach subgroups) – in order to avoid excluding those who do not have access to mobile devices and the internet.
- Apply weighting adjustments to the survey data in an effort to address potential issues arising from any sampling bias. For example, a weight adjustment could be conducted to account for any significant differences between the survey samples and the general Australian population according to ABS statistics.
- Conduct a more in-depth analysis of potential geographic and climatic/weather-based differences in firewood consumption across Australia. For example, future research that takes into consideration how residential firewood consumption differs between climate zones in each state and territory could bring additional insights to the results presented in this report, especially in states and/or territories that cover several climate zones.
- Compare the effectiveness of using different methodologies and approaches to collect data on residential firewood consumption over time. This could include testing different data collection methods (e.g. online, app-based, face-to-face) and exploring whether there is an optimal frequency and/or duration of reporting (e.g. daily, weekly, monthly, seasonally,

yearly, etc.) that reduces participants' recollection bias, thereby leading to more accurate self-report estimates of firewood consumption. Relatedly, more frequent surveying may have the benefit of allowing more fine-grained data collection over time (i.e. measuring the frequency and duration of firewood use at different times of the year, such as how many hours per day and/or days per week firewood is used across the various seasons).

- Linking objectively measured weather data – such as daily temperature and heating degree days (HDDs) – with longitudinal self-report data on firewood use, particularly if such data is collected over a specific timeframe (e.g. past day/week) or across different seasons of the year (e.g. winter vs. summer). Such an analysis may enable an empirical investigation of the potential impact of temperature and HDD variation (if present) on firewood consumption, both between and within different Australian states and territories.
- Develop and provide more specific guidelines/instructions to help survey respondents with the accurate identification and reporting of different wood species used for residential firewood, as well as methods for converting between volume and weight for each species, in order to minimise the risk of measurement error. This could include asking respondents to measure the amount of firewood they use before it is burned and/or keeping a diary or written record of the amount of firewood consumed over a specific time-period (i.e. during the winter months).

7.4 Concluding comments

The current research extended on the CSIRO's earlier study of residential firewood consumption in Australia by conducting two additional surveys to collect new primary data from a large sample of households across the country. In parallel, a range of statistical analyses have been conducted to better understand the key characteristics of firewood vs. non-firewood users, the primary drivers of residential wood consumption, and typical patterns and behaviours associated with firewood use (e.g. methods of sourcing wood, frequency and duration of wood consumption). Importantly, the current research has also produced more up-to-date estimates of residential firewood consumption for each Australian state and territory, in an effort to improve the accuracy and robustness of existing estimates published as part of the Australian Energy Statistics. There are multiple avenues for future research and analysis that may further strengthen the scientific validity, reliability and generalisability of results presented herein. We encourage additional research in this area over time in order to build a more comprehensive and complete understanding of residential firewood consumption in Australia.

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9 Appendix

9.1 2019 Survey 1: CSIRO Energise

#	Variable	Question	Format
1	Use of wood for domestic purposes	To get started, can you please confirm whether your household uses wood as a source of energy or fuel at home? This includes the use of wood for household heating (e.g. fireplace), cooking (e.g. wood-burning oven, stove, cooktop, BBQ), hot water (e.g. wood-fired system) and other domestic purposes where wood is burned. - Yes, my household uses wood as an energy/fuel source → *Go to Intro 1 text* - No, my household does not use wood as an energy/fuel source → *Go to Q18*	Single-select list *Mandatory opening item
First subset of questions – household that use wood			
	Intro 1 text	The remainder of this survey is about wood-fired appliances in the home. For the purpose of this survey, please interpret 'wood-fired appliance' as any appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplaces), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems. Please tap 'NEXT' to continue.	Display text only
2	Specific purpose(s) of wood used	First, does your household use wood for indoor space heating? Examples include fireplaces and other wood-fired appliances that are specifically used to heat the indoor rooms of your home. - Yes → *Go to next question* - No → *Go to Intro 2*	Multi-select list
3	Age of wood heater used most often	Thinking specifically about your household's wood heater/heating system, approximately how old is it? *If your home has more than one wood heater (e.g. multiple fireplaces), please give the age of the wood heater your household uses most often.* - Pre-1992 - 1992 to 2000 - 2001 to 2015 - 2016 to present - Don't know	Single-select list
4	Main type of heating this winter	In the past 12 months, was wood heating (e.g. fireplace) the main type of space heating used by your household? - Yes - No	Single-select list
5	Months of year when wood heating is used	Which months of the year do you usually use wood-fired appliances for space heating? (select all that apply) - January - February - March - April - May - June - July - August - September	Multi-select list

		- October - November - December	
6	Use of wood-heater (cooler months)	Thinking about this winter, on average, how many days per week did your household use one or more wood-fire appliances for space heating? *A response of 0 goes to Q8*	Numeric. Valid range 0 to 7 with 2 decimals
7	Use of wood-heater (cooler months)	On these cooler days of the year when wood heating was used, on average, how many hours per day did your household use at least one wood-fired appliance for space heating?	Numeric. Valid range 1 to 24 with 2 decimals
8	Use of wood heater (days/week)	Now thinking specifically about the past seven days, on how many days did your household use one or more wood-fired appliances for space heating? *If you did not use any wood heating in the past seven days, please answer '0'.* *A response of 0 goes to Intro 2*	Numeric. Valid range 0 to 7
9	Use of wood heater (hours/day)	Thinking about yesterday, approximately how many hours did your household use at least one wood-fired appliance for space heating? *If you did not use any wood heating yesterday, please answer '0'.*	Numeric. Valid range 0 to 24 with 2 decimals
	Intro 2 text	These next few questions are specifically about your household's use of wood-fired appliances for purposes other than indoor space heating. This includes the use of wood for cooking (e.g. wood-fired oven, stove, cooktop, BBQ), hot water heating, and outdoor heating (e.g. outdoor fireplace). Please tap 'NEXT' to continue.	
10	Use of wood for other non-heating purposes	Does your household use wood for any of the following at home? (select all that apply) - Hot water system → *Go to next question (*override)* - Cooktop and/or oven → *Go to next question (*override)* - Outdoor barbeque/pizza oven → *Go to next question (*override)* - Outdoor heating → *Go next question (*override)* - None of the above → *Go to Question 13*	Multi-select list
11	Use of wood-fired appliances (other purposes	Thinking about the past 12 months, on average, how many days per week did your household use one or more wood-fired appliances for purposes other than indoor space heating? *A response of 0 goes to Q13*	Numeric. Valid range 0 to 7 with 2 decimals
12	Use of wood-fired appliances (other purposes	On these days, on average, how many hours per day did your household use at least one wood-fired appliance for purposes other than indoor space heating?	Numeric. Valid range 1 to 24 with 2 decimals
13	Number of wood-fired appliances	Now thinking about all of the wood-fired appliances that you have at home for any purpose (e.g. for space heating, cooking, hot water etc.), how many wood-fired appliances does your household use in total?	Numeric. Valid range 1 to 15
14	Source of wood	Thinking about all the wood used by your household in the past 12 months (e.g. for space heating, cooking, hot water etc.), how was this wood sourced? (select all that apply) - Wood was purchased from a commercial supplier/shop - Wood was purchased from a private seller (e.g. bought from friend, neighbour, a person advertising in local newspaper/online classifieds, etc.) - Wood was self-collected (e.g. gathered from property, bush, etc.) - Wood was given by others for free (e.g. friends, family, neighbour)	Multi-select list

		- Wood was sourced another way (please specify):	
15	Type of wood	In the past 12 months, what type(s) of wood did your household use most often? (select all that apply) - Softwood (e.g. Pine, Cypress, Cedar) - Hardwood (e.g. Redgum, Bluegum, Sugar Gum, Ironbark, Stringy Bark, Yellow/Grey Box, Jarrah, other Eucalypts) - Other (please specify): - Don't know *Contextual help: Generally speaking, hardwood trees tend to be slower growing and are often (but not always) heavier and denser than softwoods. Hardwoods typically burn slower and provide heat/warmth for longer than lower-density softwoods*	Multi-select list
	Intro 4	The next question asks about the total amount of wood used by your household's wood-fired appliance(s) in the past 12 months. Please count all types of wood used for energy/fuel, regardless of the source (e.g. purchased, self-collected or received for free). The quantity of wood used by your household can be measured in several ways – for instance by weight (e.g. kilograms or tonnes), volume (e.g. cubic metres), or lot (e.g. small, medium or large trailer/truck loads). For the next question, please answer in terms of whatever metric allows you to most accurately estimate the total amount of wood used for your household's wood-fired appliances in the past year. Please tap 'NEXT' to continue.	Display text only
16	Quantity of wood used	Thinking about the past 12 months, approximately how much wood did your household use in total? In your response, please give both the amount and the unit of measurement, e.g. "1 tonne", "1 cubic metre", "1 standard-sized (6 x 4 foot) trailer load", etc. *If you don't know the answer, please leave the question blank and tap 'NEXT' to continue.*	Open-text, max 100 characters
17	Proportion of recycled or scrap wood	Of the total amount of wood used by your household in the past 12 months, approximately what proportion was recycled wood or offcuts? This includes leftover or scrap wood from sawmills, building, carpentry activities, etc. - 0% – none of the wood used by household was recycled/offcuts - 1-24% – less than one quarter of all wood used by household was recycled/offcuts - 25-49% – one quarter to less than one half of all wood used by household was recycled/offcuts - 50-74% – one half to less than three quarters of all wood used by household was recycled/offcuts - 75-99% – three quarters or more of all wood used by households was recycled/offcuts - 100% – all of the wood used by household was recycled/offcuts - Don't know	Single-select list
Second subset of questions – household that do not use wood			
18	Prior fuel switching (away from wood)	In the past five years, has your household upgraded or replaced any wood-fired appliances with an electric, gas or solar appliance? Examples include replacing a wood heater (e.g. fireplace) with electric or gas heating; switching from a wood-burning oven/stove to an electric or gas cooking appliance; or replacing wood-fired hot water with an electric, gas or solar hot water system. - No - Yes - Don't know	Single-select list

		Contextual help: For this question, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplace), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems.	
19	Future intentions to install / purchase wood appliance	Does your household plan to purchase or install any new wood-fired appliances in the future? Examples include installing a wood heater (e.g. fireplace) or wood-burning hot water system, or buying a wood-fired cooking appliance (e.g. oven, stove, cooktop, BBQ). - No - Yes, in the short-term future (i.e. within 2 years) - Yes, in the medium-term future (i.e. 3-5 years) - Yes, in the long-term future (i.e. more than 5 years) - Don't know *Contextual help: For this question, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplace), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems.*	Single-select list
20	End of survey	That's the end of the survey! If you had any problems completing this survey, you can leave a comment below. Otherwise, please tap SUBMIT to finish.	Open-text, max 200 characters

9.2 2019 Survey 2: Online panel

#	Variable	Question	Format
Before the main survey questions, the panel provider's templated panel module was presented. This module captured AGE, GENDER and POSTCODE and is used by the panel provider for internal purposes only (e.g. to facilitate sampling and feasibility, to monitor/ensure that the survey invitations are deployed in demographically balanced proportions, to track the require quotas etc.). Data from these preliminary questions does not form part of the survey dataset itself.			
1	Year of birth Postcode	To get started, could you please re-confirm your **year of birth** and **postcode**? It's important for this research that we collect accurate information, so we appreciate you confirming these details. (please enter a numeric answer for each field below)	Numeric. Valid range for year of birth: 1906 to 2001 Valid range for postcode: 0800 to 7999
2	Dwelling type	What type of dwelling do you live in? - Separate house - Semi-detached, row or terrace house or townhouse (e.g. duplex or villa) - Flat, unit or apartment - Other type of dwelling - Prefer not to say	Single-select list
3	Dwelling age	Approximately, in what year was your home constructed? - Pre-1970 - 1970-1979 - 1980-1989 - 1990-1999 - 2000-2009 - 2010-2015 - 2016-present - Don't know - Prefer not to say	Single-select list

4	Tenure type	In terms of home ownership, is your dwelling: - Owned or partly owned by someone in your household - Being rented by your household - Other (e.g. occupied rent-free) - Prefer not to say	Single-select list
5	Household size	Including yourself, how many people usually live in your household? *In some households, the number of occupants can vary from time to time. Please answer this question in terms of the number of people who live in your home at least half of the time.*	Numeric. Valid range 1 to 20
6	Household type	Which of the following best describes your household? - Lone person household - single person living alone - One family household - couple with no children - One family household - couple with children (including adult children) - One family household - one parent family with children (including adult children) - Multiple family household - two or more families (e.g. extended family grouping) - Group household - two or more unrelated persons (e.g. share-house) - Other type of household - Prefer not to say	Single-select list
7	Household Income	What is your <u>total household income</u> per year, before tax? That is, the total of all wages/salaries, government benefits, pensions, allowances and other income (e.g. dividends, interest) your household usually receives. Do not deduct tax. - Less than $15,600 per year - $15,600 – $33,799 per year - $33,800 – $51,999 per year - $52,000 – $77,999 per year - $78,000 – $103,999 per year - $104,000 – $129,999 per year - $130,000 – $181,999 per year - $182,000 – $259,999 per year - $260,000 or more per year - Prefer not to say	Single-select list
8	Energy sources (mapped to Energy sources)	Which of the following energy sources does your household use? (select all that apply). - Electricity - Mains gas - Bottled gas/LPG - Solar (solar electricity or solar hot water) - Prefer not to say [EXCLUSIVE]	Multi-select list
9	Use of wood for domestic purposes	Does your household use wood as a source of energy or fuel at home? *This includes the use of wood for household heating (e.g. fireplace), cooking (e.g. wood-burning oven, stove, cooktop, BBQ), hot water (e.g. wood-fired system) and other domestic purposes where wood is burned.* - Yes, my household uses wood as an energy/fuel source → *Go to Intro 1* - No, my household does not use wood as an energy/fuel source → *Go to Q27*	Single-select list *Mandatory screening item approved
First subset of questions – household that use wood			
	Intro text 1	This section of the survey is about wood-fired appliances in the home. For the purpose of this survey, please interpret 'wood-fired appliance' as any appliance or structure that uses wood as a source of energy or fuel. This	Display text only

		includes wood heaters (e.g. fireplaces), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems. Please tap 'NEXT' to continue.	
10	Specific purpose(s) of wood used	First, does your household use wood for indoor space heating? Examples include fireplaces and other wood-fired appliances that are specifically used to heat the indoor rooms of your home. - Yes → *Go to next question* - No → *Go to Intro 2*	Single-select list *Mandatory item approved
11	Age of wood heater used most often	Thinking specifically about your household's wood heater/heating system, approximately how old is it? *If your home has more than one wood heater (e.g. multiple fireplaces), please give the age of the wood heater your household uses most often.* - Pre-1992 - 1992 to 2000 - 2001 to 2015 - 2016 to present - Don't know - Prefer not to say	Single-select list
12	Months of year when wood heating is used	Which months of the year do you usually use wood-fired appliances for space heating? (select all that apply) - January - February - March - April - May - June - July - August - September - October - November - December - Prefer not to say [EXCLUSIVE]	Mulit-select
13	Use of wood-heater (cooler months)	Thinking about this winter, on average, how many days per week did your household use one or more wood-fire appliances for space heating? *A response of 0, or blank, goes to Q16; else if >0, continue to Q15.*	Numeric. Valid range 0 to 7 with 2 decimals
14	Use of wood-heater (cooler months)	On these cooler days of the year when wood heating was used, on average, how many hours per day did your household use at least one wood-fired appliance for space heating?	Numeric. Valid range 0.1 to 24 with 2 decimals
15	Use of wood heater (days/week)	Now thinking specifically about the past seven days, on how many days did your household use one or more wood-fired appliances for space heating? *If you did not use any wood heating in the past seven days, please answer '0'.* *A response of 0, or blank, goes to Q18; else if >0, continue to Q17.*	Numeric. Valid range 0 to 7
16	Use of wood heater (hours/day)	Thinking about yesterday, approximately how many hours did your household use at least one wood-fired appliance for space heating? *If you did not use any wood heating yesterday, please answer '0'.*	Numeric. Valid range 0 to 24 with 2 decimals
17	Main type of heating this winter	In the past 12 months, was wood heating (e.g. fireplace) the main type of space heating used by your household? - Yes - No, electric heating was main type - No, gas heating was main type	Single-select list

		- No, other heating was main type (please specify): - Prefer not to say	
	Intro 2 text	These next few questions are specifically about your household's use of wood-fired appliances for purposes other than indoor space heating. This includes the use of wood for cooking (e.g. wood-fired oven, stove, cooktop, BBQ), hot water heating, and outdoor heating (e.g. outdoor fireplace). Please tap 'NEXT' to continue.	Display text only
18	Use of wood for other non-heating purposes	Does your household use wood for any of the following at home? (select all that apply) - Hot water system→ *Go to next question (*override)* - Cooktop and/or oven → *Go to next question (*override)* - Outdoor barbeque/pizza oven→ *Go to next question (*override)* - Outdoor heating → *Go next question (*override)* - None of the above → *Go to Question 22 (*exclusive option, if selected other responses cannot be selected)*	Multi-select list *Mandatory item approved
19	Use of wood-fired appliances (other purposes)	Thinking about the past 12 months, on average, how many days per week did your household use one or more wood-fired appliances for purposes other than indoor space heating? *A response of 0, or blank, goes to Q22; else if >0, continue to Q21.*	Numeric. Valid range 0 to 7 with 2 decimals
20	Use of wood-fired appliances (other purposes)	On these days, on average, how many hours per day did your household use at least one wood-fired appliance for purposes other than indoor space heating?	Numeric. Valid range 0.1 to 24 with 2 decimals
21	Number of wood-fired appliances	Now thinking about all of the wood-fired appliances that you have at home for any purpose (e.g. for space heating, cooking, hot water etc.), how many wood-fired appliances does your household use in total?	Numeric. Valid range 1 to 15
22	Source of wood	Thinking about all the wood used by your household in the past 12 months (e.g. for space heating, cooking, hot water etc.), how was this wood sourced? (select all that apply) - Wood was purchased from a commercial supplier/shop - Wood was purchased from a private seller (e.g. bought from friend, neighbour, a person advertising in local newspaper/online classifieds, etc.) - Wood was self-collected (e.g. gathered from property, bush, etc.) - Wood was given by others for free (e.g. friends, family, neighbour) - Wood was sourced another way (please specify): - Prefer not to say [EXCLUSIVE]	Multi-select list
23	Type of wood	In the past 12 months, what type(s) of wood did your household use most often? (select all that apply) *Generally speaking, hardwood trees tend to be slower growing and are often (but not always) heavier and denser than softwoods. Hardwoods typically burn slower and provide heat/warmth for longer than lower-density softwoods* [RANDOMIZE ORDER OF OPTIONS 1 AND 2] - Softwood (e.g. Pine, Cypress, Cedar) - Hardwood (e.g. Redgum, Bluegum, Sugar Gum, Ironbark, Stringy Bark, Yellow/Grey Box, Jarrah, other Eucalypts) - Other (please specify): [ANCHOR] - Don't know [ANCHOR; EXCLUSIVE] - Prefer not to say [ANCHOR; EXCLUSIVE]	Multi-select list
	Intro text 3	The next question asks about the total amount of wood used by your household's wood-fired appliance(s) in the past 12 months. Please count all	Display text only

		types of wood used for energy/fuel, regardless of the source (e.g. purchased, self-collected or received for free). The quantity of wood used by your household can be measured in several ways – for instance by weight (e.g. kilograms or tonnes), volume (e.g. cubic metres), or lot (e.g. small, medium or large trailer/truck loads). For the next question, please answer in terms of whatever metric allows you to most accurately estimate the total amount of wood used for your household's wood-fired appliances in the past year. Please tap 'NEXT' to continue.	
24	Quantity of wood used	Thinking about the past 12 months, approximately how much wood did your household use in total? In your response, please give both the amount and the unit of measurement, e.g. "1 tonne", "1 cubic metre", "1 standard-sized (6 x 4 foot) trailer load", etc.	Open-text, max 100 characters *Mandatory item approved
25	Proportion of recycled or scrap wood	Of the total amount of wood used by your household in the past 12 months, approximately what proportion was recycled wood or offcuts? This includes leftover or scrap wood from sawmills, building, carpentry activities, etc. - 0% – none of the wood used by household was recycled/offcuts - 1-24% – less than one quarter of all wood used by household was recycled/offcuts - 25-49% – one quarter to less than one half of all wood used by household was recycled/offcuts - 50-74% – one half to less than three quarters of all wood used by household was recycled/offcuts - 75-99% – three quarters or more of all wood used by households was recycled/offcuts - 100% – all of the wood used by household was recycled/offcuts - Don't know - Prefer not to say	Single-select list
26	Prior fuel switching (away from wood)	In the <u>past five years</u>, has your household upgraded or replaced any wood-fired appliances with an electric, gas or solar appliance? Examples include replacing a wood heater (e.g. fireplace) with electric or gas heating; switching from a wood-burning oven/stove to an electric or gas cooking appliance; or replacing wood-fired hot water with an electric, gas or solar hot water system. *For this question, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplace), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems.* - No - Yes - Don't know - Prefer not to say	Single-select list
27	Future intentions to install / purchase wood appliance	Does your household plan to purchase or install any new wood-fired appliances in the future? Examples include installing a wood heater (e.g. fireplace) or wood-burning hot water system, or buying a wood-fired cooking appliance (e.g. oven, stove, cooktop, BBQ). *For this question, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplace), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems.* - No - Yes, in the short-term future (i.e. within 2 years) - Yes, in the medium-term future (i.e. 3-5 years) - Yes, in the long-term future (i.e. more than 5 years) - Don't know	Single-select list

		- Prefer not to say	
	End of survey	That's the end of the survey! If you had any problems completing this survey, you can leave a comment below. Otherwise, please tap 'Next' to finish.	Open-text, max 200 characters

9.3 2018 Survey: CSIRO Energise

#	Variable	Question	Format
1	Use of wood for domestic purposes	To get started, can you please confirm whether your household uses wood as a source of energy or fuel at home? This includes the use of wood for household heating (e.g. fireplace), cooking (e.g. wood-burning oven, stove, cooktop, BBQ), hot water (e.g. wood-fired system) and other domestic purposes where wood is burned. - Yes, my household uses wood as an energy/fuel source → *Go to Q2* - No, my household does not use wood as an energy/fuel source → *Go to Q16*	Single-select list *Mandatory opening item
First subset of questions – household that use wood			
2	Specific purpose(s) of wood used	What does your household use wood for? (select all that apply) - Heating (e.g. fireplace) → *Go to Q3 (*override)* - Hot water system → *Go to Q5* - Cooktop and/or oven → *Go to Q5* - Outdoor barbeque/pizza oven → *Go to Q5* - Other (please specify): → *Go to Q5*	Multi-select list
3	Age of wood heater used most often	Thinking specifically about your household's wood heater/heating system, approximately how old is it? *If your home has more than one wood heater (e.g. multiple fireplaces), please give the age of the wood heater your household uses most often.* - Pre-1992 - 1992 to 2000 - 2001 to 2015 - 2016 to present - Don't know	Single-select list
4	Main type of heating this winter	In the past 12 months, was wood heating (e.g. fireplace) the main type of heating used by your household? - Yes - No	Single-select list
	Filler text	The next few questions ask about your household's use of wood-fired appliances. For these questions, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplaces), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems. Please tap 'NEXT' to continue.	Display text only
5	Number of wood-fired appliances	Thinking about the past 12 months, how many different wood-fired appliances did your household use in total?	Numeric. Valid range 1 to 15
6	Use of wood-fired appliances (cooler months)	Thinking about the cooler months of this year (e.g. April to September 2018), on average, how many days per week did your household use one or more wood-fired appliances? *A response of 0 goes to Q8*	Numeric. Valid range 0 to 7 with 1 decimal

7	Use of wood-fired appliances (cooler months)	On these cooler days of the year when a wood-fired appliance was used, on average, how many hours per day did your household use at least one wood-fired appliance? *Please give your best estimate, rounding to the nearest whole hour.*	Numeric. Valid range 1 to 24 with 1 decimal
8	Use of wood-fired appliances (warmer months)	Now thinking about the warmer months of this year and late last year (e.g. October 2017 to March 2018), on average, how many days per week did your household use one or more wood-fired appliances? *A response of 0 goes to Q10*	Numeric. Valid range 0 to 7 with one decimal
9	Use of wood-fired appliances (warmer months)	On these warmer days of the year when a wood-fired appliance was used, on average, how many hours per day did your household use at least one wood-fired appliance? *Please give your best estimate, rounding to the nearest whole hour.*	Numeric. Valid range 1 to 24 with 1 decimal
10	Use of wood days/week	In the past seven days, how many days did your household use one or more wood-fired appliances? *If you did not use a wood-fired appliance in the past seven days, please answer '0'.* *A response of 0 goes to Q10*	Numeric. Valid range 0 to 7
11	Use of wood hours/day	Thinking about yesterday, approximately how many hours did your household use at least one wood-fired appliance? *If you did not use any wood-fired appliances yesterday, please answer '0'.*	Numeric. Valid range 0 to 24 with 1 decimal
12	Source of wood	In the past 12 months, how was your household's wood sourced? (select all that apply) - Wood was purchased from a commercial supplier/shop - Wood was purchased from a private seller (e.g. bought from friend, neighbour, a person advertising in local newspaper/online classifieds, etc.) - Wood was self-collected (e.g. gathered from property, bush, etc.) - Wood was given by others for free (e.g. friends, family, neighbour) - Wood was sourced another way (please specify):	Multi-select list
13	Type of wood	In the past 12 months, what type(s) of wood did your household use most often? (select all that apply) - Softwood (e.g. Pine, Cypress, Cedar) - Hardwood (e.g. Redgum, Bluegum, Sugar Gum, Ironbark, Stringy Bark, Yellow/Grey Box, Jarrah, other Eucalypts) - Other (please specify): - Don't know *Contextual help: Generally speaking, hardwood trees tend to be slower growing and are often (but not always) heavier and denser than softwoods. Hardwoods typically burn slower and provide heat/warmth for longer than lower-density softwoods*	Multi-select list
	Filler text	The next question asks about the total amount of wood used by your household's wood-fired appliances in the past 12 months. Please count all types of wood used for energy/fuel, regardless of the source (e.g. purchased, self-collected or received for free). The quantity of wood used by your household can be measured in several ways – for instance by weight (e.g. kilograms or tonnes), volume (e.g. cubic metres), or lot (e.g. small, medium or large trailer/truck loads). For the next question, please answer in terms of whatever metric allows you to most accurately estimate the total amount of wood used for your household's wood-fired appliances in the past year. Please tap 'NEXT' to continue.	Display text only

14	Quantity of wood used	Thinking about the past 12 months, approximately how much wood did your household use in total? In your response, please give both the amount and the unit of measurement, e.g. "1 tonne", "1 cubic metre", "1 standard-sized (6 x 4 foot) trailer load", etc. *If you don't know the answer, please leave the question blank and tap 'NEXT' to continue.*	Open-text, max 100 characters
15	Proportion of recycled or scrap wood	Of the total amount of wood used by your household in the past 12 months, approximately what proportion was recycled wood or offcuts? This includes leftover or scrap wood from sawmills, building, carpentry activities, etc. - 0% – none of the wood used by household was recycled/offcuts - 1-24% – less than one quarter of all wood used by household was recycled/offcuts - 25-49% – one quarter to less than one half of all wood used by household was recycled/offcuts - 50-74% – one half to less than three quarters of all wood used by household was recycled/offcuts - 75-99% – three quarters or more of all wood used by households was recycled/offcuts - 100% – all of the wood used by household was recycled/offcuts - Don't know	Single-select list
Second subset of questions – household that do not use wood			
16	Prior fuel switching (away from wood)	In the past five years, has your household upgraded or replaced any wood-fired appliances with an electric, gas or solar appliance? Examples include replacing a wood heater (e.g. fireplace) with electric or gas heating; switching from a wood-burning oven/stove to an electric or gas cooking appliance; or replacing wood-fired hot water with an electric, gas or solar hot water system. - No - Yes - Don't know *Contextual help: For this question, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplace), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems.*	Single-select list
17	Future intentions to install / purchase wood appliance	Does your household plan to purchase or install any new wood-fired appliances in the future? Examples include installing a wood heater (e.g. fireplace) or wood-burning hot water system, or buying a wood-fired cooking appliance (e.g. oven, stove, cooktop, BBQ). - No - Yes, in the short-term future (i.e. within 2 years) - Yes, in the medium-term future (i.e. 3-5 years) - Yes, in the long-term future (i.e. more than 5 years) - Don't know *Contextual help: For this question, please interpret 'wood-fired appliance' as an appliance or structure that uses wood as a source of energy or fuel. This includes wood heaters (e.g. fireplace), cooking appliances (e.g. wood-fired oven, stove, cooktop, BBQ) and wood-burning hot water systems.*	Single-select list
18	Other comments	In terms of households using wood as an energy/fuel source, is there anything else you would like to tell us before finishing the survey?	Open-text, max 2000 characters

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