frontier economics

# Residential energy consumption benchmarks

Final report for the Australian Energy Regulator | 9 December 2020

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# 1 Introduction

The National Energy Retail Rules (NERR) require the Australian Energy Regulator (AER) to develop electricity consumption benchmarks for residential customers. The purpose of the electricity benchmarks is to allow residential consumers to compare their usage with similar households in their area. This in turn assists consumers to make more informed choices about how they use energy. Under Rule 169 of the NERR, the electricity consumption benchmarks must be based on:

- Electricity consumption information provided to the AER by distributors
- Localised zones as determined by jurisdictional ministers responsible for energy
- Household size.

The AER is required to:

- Provide the benchmarks to electricity retailers
- Publish the benchmarks on the AER website
- Provide supporting information to the Ministerial Council on Energy (MCE).

The requirement to develop benchmarks applies to the jurisdictions governed under the National Energy Retail Law (NERL) – that is Queensland, New South Wales, Australian Capital Territory, South Australia and Tasmania.

Under the NERR the AER is required to update the benchmarks at least every three years from the date when the initial benchmarks were published. To date benchmarks have been produced in 2011, 2014, and 2017. In 2017, the benchmarks were expanded to include residential gas consumption benchmarks.

Although not required under the NERR, the AER previously developed electricity consumption benchmarks for Victoria and the Northern Territory. The updated benchmarks presented in this report include Victoria. However due to challenges in previous years in recruiting sufficiently large and representative samples to develop accurate benchmarks in the Northern Territory, and the lack of requirement on retailers to display the benchmarks, the updated benchmarks do not include the Northern Territory.

The NERR places obligations on electricity retailers to display the consumption benchmarks on residential customer bills. Under Rule 170, retailers must include the following information on customer bills:

- A comparison of the customer's electricity consumption against the benchmarks
- A statement indicating the purpose of the benchmark information
- Reference to an energy efficiency website.

The AER also uses data collected through this process to develop separate energy consumption benchmarks for Energy Made Easy (EME, the Australian Government’s energy plan comparison website) and to develop Basic Plan Information Documents (BPIDs). For EME, the benchmarks are used to provide an estimate of electricity or gas consumption for residential customers without complete data on their energy usage. This is used as an input to estimate the bills under different electricity and gas plans.

Benchmarks are available in EME that are more tailored to a range of energy consumer characteristics – for example, for particular household sizes, appliance stocks, and energy services used (e.g. controlled load). This ensures the benchmark used by customers to compare plans relates to their likely level of energy usage.

BPIDs are documents that include important information about an energy plan. They are standard templates, developed by the AER, which retailers must use to ensure that information is provided to consumers in a consistent format across retailers and plans. For the BPIDs, the benchmarks are used to estimate bills in a consistent manner for representative levels of electricity consumption.

### 1.1.1 Scope of our engagement

Frontier Economics was engaged by the AER to assist it in producing the 2020 energy consumption benchmarks by:

- Updating the existing household electricity consumption benchmarks for localised zones in the required jurisdictions (Queensland, New South Wales, Australian Capital Territory, South Australia, Tasmania) and Victoria
- Updating gas consumption benchmarks for the same jurisdictions at the jurisdiction level
- Updating seasonal weightings
- Providing advice on future benchmark development.

## 1.2 Report structure

The remainder of this report is structured as follows:

- Section 2 sets out our approach to collecting and processing survey data and energy consumption data
- Section 3 provides a summary and description of the survey and energy consumption datasets
- Section 4 sets out our methodology and results for the electricity consumption benchmarks
- Section 5 sets out our methodology and results for the gas consumption benchmarks
- Section 6 provides advice on the development of future consumption benchmarks.

Appendices provide additional detailed information:

- Appendix A provides a technical overview of the data cleaning and processing undertaken to generate seasonal consumption estimates
- Appendix B provides a technical overview of the electricity consumption benchmark models
- Appendix C provides a technical overview of the gas consumption benchmark models
- Appendix D contains the household survey questions

- Appendix E shows seasonal electricity consumption by climate zone
- Appendix F shows seasonal gas consumption by jurisdiction.

# 2 Data collection

This section describes the survey data collection, which is used as an input to calculate the benchmarks. It also summarises the electricity and gas consumption data collection and cleaning.

## 2.1 Collecting survey data

Frontier Economics partnered with the Online Research Unit (ORU) to conduct an online survey of residential energy consumers. Broadly, the purpose of the survey was twofold:

1. To collect data on the characteristics of households relevant to energy consumption
2. To collect identifying information to allow us to link the survey responses with the survey participant's metered energy consumption data.

We collected survey responses in two tranches:

1. Primary data collection through an online panel maintained by the ORU
2. Supplementary data collection through open links distributed by the AER.

The primary recruitment for the survey was through the ORU's 'Australian Consumer Panel' (ACP). The ACP is made up of approximately 350,000 members across Australia. It is described by the ORU as the largest consumer panel in Australia.

Frontier Economics developed the survey questionnaire in collaboration with the AER and the ORU. It is broadly based on the survey used to produce the 2017 benchmarks[1] with modifications to reduce the length of the survey and capture characteristics of energy consumption that have emerged in recent years e.g. wider scale installation of solar and batteries. The full set of survey questions is provided for reference in Appendix D.

The survey collected the following broad categories of information:

- Explicit informed consent from respondents to participate in the study
- Basic demographic information for the respondent and household
- Characteristics of the dwelling relevant to energy consumption (such as type and size)
- Type of appliances used for common energy requirements (such as space heating and cooling, water heating, and cooking)
- Characteristics of the energy supply (such as solar PV panels, gas, controlled load)

[1] ACIL Allen, 2017, *Bill Benchmarks Household dataset variable lists*. Online at https://www.aer.gov.au/retail-markets/guidelines-reviews/electricity-and-gas-bill-benchmarks-for-residential-customers-2017/decision

- Energy consumption identifiers – in particular, the National Metering Identifier (NMI) for electricity and Meter Installation Reference Number (MIRN) for gas.[2]

The survey data supports the development of the consumption benchmarks and is also used by the AER for broader requirements, for example for the development of consumption estimates for EME and BPIDs.

To allow respondents' survey data to be matched with energy consumption data, their electricity NMI and their gas MIRN (if they indicated they have a mains gas connection) were collected. Respondents were given guidance on how to find the NMI and MIRN on their bills.

Structural checks on the NMI and MIRN were conducted to detect invalid entries.[3] If respondents provided an invalid NMI they received an error message and were redirected to find the correct value on their bill. Respondents were not able to continue with the survey until entering a valid NMI.

Survey data collection through the ORU panel was conducted from the 25th of May 2020 to the 5th of June 2020 and a total of 6,826 responses were collected. We understand respondents receive some financial compensation for completing surveys but are not aware of the particular arrangements.

Supplementary data was collected through open links distributed by the AER to internal and external channels and social media from the 5th of June 2020 to the 30th of June 2020. The open links were hosted by the ORU, and the content and presentation of questions were identical to those presented to the ORU panel. An additional 144 responses were received through the open links. The survey respondents through the open links did not receive any form of compensation. This provided a total of 6,970 survey responses.

## 2.2 Collecting and processing electricity consumption data

As described in Section 2.1, survey respondents' NMI was used to match survey responses with their metered electricity consumption data. Raw electricity consumption data was collected from two sources, the Australian Energy Market Operator (AEMO), and Distribution Network Service Providers (DNSPs, excluding Ausgrid and the Victorian DNSPs).

Some households have an interval meter, which records electricity consumption in thirty-minute intervals. Others have an accumulation meter, which records total electricity consumed over an

[2] The NMI and MIRN are 10 or 11 character strings of numbers, or numbers and letters, that uniquely identify an electricity or gas connection point. The MIRN is sometimes referred to as the Delivery Point Identifier (DPI) in NSW. For the remainder of the paper, MIRN is used to refer to either of these terms. The NMI is technically defined by the first 10 characters with the 11th functioning as a numeric 'Checksum'. For each NMI, there is only 1 valid option for the Checksum which can be derived using a simple algorithm defined by AEMO. If the 11th character is not that value, this implies an error somewhere in the NMI. It is used by AEMO to check for manual errors in NMI inputs. AEMO recommends that the 11 character version is used whenever the NMI is presented to customers. Further detail is available in the following document.

Australian Energy Market Operator, December 2017, *MSATS Procedures National Metering Identifier*. Online at https://www.aemo.com.au/-/media/files/electricity/nem/retail_and_metering/metering-procedures/2018/msats-national-metering-identifier-procedure.pdf?la=en&hash=243AA41A6FB95B4050E0B260EE56ED31#:~:text=This%20National%20Metering%20Identifier%20Procedure,matters%20contemplated%20in%20clauses%207.8.

[3] This included checks on length, type of characters, and the use of the 'Checksum' calculation for the 11th character described above. We included similar checks on the NMI and MIRN.

elapsed period of time (for example, 30 or 90 days). The most granular data available for each NMI was sought.[4]

Consumption data was collected for calendar year 2019, with some additional data on either side to ensure a complete year of data given different meter read periods.

The raw electricity consumption data was processed to produce estimates of seasonal consumption.[5] Broadly, this involved:

- Identifying all data streams representing 'Import' values for each NMI and aggregating these
- Reconciling AEMO data and DNSP data
- Allocating accumulation meter consumption data to a season based on the number of days in the read period that fall within each season
- Matching the electricity consumption data to the respondents in the survey data.

Overall, 6,547 respondents were matched to electricity consumption data, a match rate of 94%. A small number of respondents were removed from the electricity sample. This included 78 that reported operating an energy intensive business from their household, and 4 that provided a location and NMI that were inconsistent (for example a household in Sydney that provided a South Australian NMI). The final sample size was 6,465 households.

A detailed description of the data cleaning and processing undertaken to develop seasonal electricity consumption benchmarks is set out in Appendix A.

## 2.3 Collecting and processing gas consumption data

Survey respondents who indicated that they had a mains gas connection were asked to provide their MIRN, which was used to match their survey responses with their gas consumption data. All gas consumption data was collected directly from the gas distribution networks. Consumption data was collected for calendar year 2019, with some additional data on either side to ensure a complete year of data given different meter read periods.

All gas consumption data is accumulation meter data. However, gas metering data has a higher proportion of 'estimated' reads. These occur when the gas network has not completed a physical meter read for a customer, but requires an estimate of gas consumption for billing purposes. Estimated reads were not used as they can differ significantly from actual consumption.[6]

The raw gas consumption data was processed to produce estimates of seasonal consumption. Broadly, this involved:

[4] AEMO and DNSPs store electricity consumption data in different formats which has a minor impact on measured consumption for customers with an interval meter and solar PV. This results in minor differences between the two sources, but did not impact the validity of the estimated benchmarks.

[5] There are several ways that electricity consumption can be measured. For the purpose of the benchmarks, we use gross import from the electricity grid – supplied by the DNSP.

[6] For example there are instances where actual gas consumption over a period of months is much lower than the estimated reads made during the interim, and the next actual read is lower than the previous estimated read. In these cases the network effectively makes a negative adjustment, to square off the difference. This can result in volatile seasonal consumption estimates, so we only use the actual meter reads.

- Removing estimated reads, as only the actual reads were used to develop seasonal consumption
- Allocating consumption data to a season based on the number of days in the read period that fall within each season
- Matching the gas consumption data to respondents in the survey data.

Overall 3,163 respondents with gas were matched with gas consumption data, a match rate of 94%. However for 15 of these the recorded gas consumption was 0 in every meter read period and they were removed from the sample. The final gas sample size was 3,148 households.

A detailed description of the data cleaning and processing used to develop seasonal gas consumption benchmarks is set out in Appendix A.

# 3 Data summaries

This section defines the localised zones selected by jurisdictional ministers responsible for energy as the basis for the consumption benchmarks and summarises the survey and energy consumption datasets.

## 3.1 Localised zones for electricity benchmarks

Under NERR rule 169(3)(B), the AER must develop electricity consumption benchmarks by localised zones, as determined and notified to the AER by the relevant jurisdictional Ministers. The jurisdictional Ministers have chosen to continue with the same zones as used for the 2017 benchmarks.[7]

### Zones for jurisdictions other than South Australia

For jurisdictions other than South Australia, the 'Climate zones' developed by the Australian Building Codes Board (ABCB) for the National Construction Code are used. There are eight ABCB climate zones, based on Bureau of Meteorology climate data. The eight climate zones are summarised in **Table 1** below, with descriptions of the zones and some examples of regions in each.

[7] ACIL Allen, 2017, *Energy Consumption Benchmarks: Electricity and Gas for Residential Customers*. Online at https://www.aer.gov.au/system/files/ACIL%20Allen%20Energy%20benchmarks%20report%202017%20-%20updated%205%20June%202018.pdf

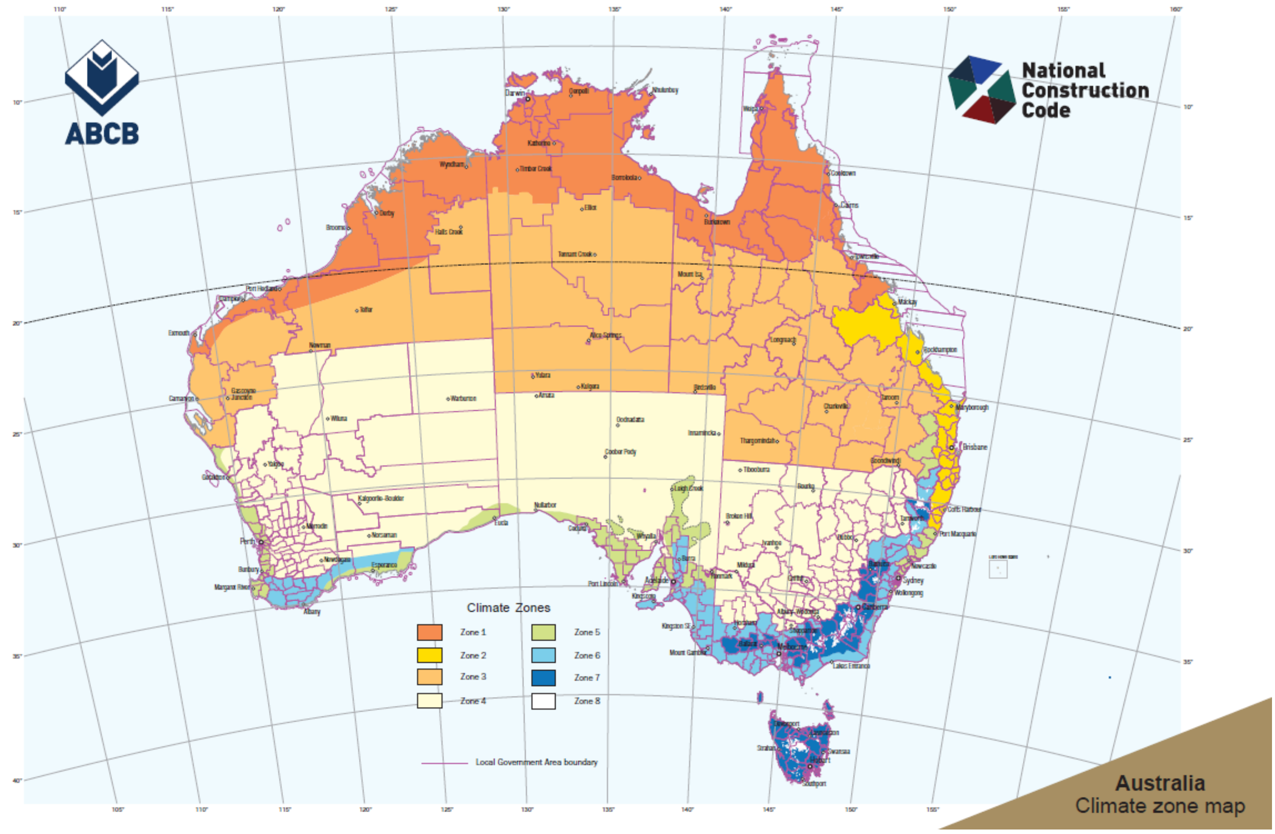
**Table 1:** Description of climate zones

| Climate zone | ABCB description | Examples |
|---|---|---|
| 1 | High humidity summer, warm winter | Cairns, Townsville |
| 2 | Warm humid summer, mild winter | Rockhampton, Brisbane, Coffs Harbour |
| 3 | Hot dry summer, warm winter | Mt Isa, Western Downs, Longreach |
| 4 | Hot dry summer, cool winter | Dubbo, Whyalla, Mildura |
| 5 | Warm temperate | Urban Sydney, urban Adelaide |
| 6 | Mild temperate | Urban Melbourne, Adelaide Hills, Ulladulla |
| 7 | Cool temperate | Canberra, Hobart, Yarra Ranges |
| 8 | Alpine | Small sections of alpine Tasmania, and the Snowy Mountains |

*Source: ABCB, Frontier Economics*

A map of the eight climate zones is presented in **Figure 1** below.

**Figure 1**: Climate zone map




*Source: ABCB*

The climate zone mapping is defined by local government area (LGA) boundaries. They do not follow broader jurisdictional boundaries. All states and territories contain two or more climate zones, and every climate zone can be found in at least two states or territories. Most LGAs are mapped to a single climate zone, with a small number of LGAs mapping to two climate zones, mostly in the alpine regions of Climate Zones 7 and 8. There are no LGAs that map only to Climate Zone 8 and it was necessary to combine it with Climate Zone 7. Through the remainder of this report, the combined zones are referred to as Climate Zone 7.

The survey respondents were mapped to an LGA and climate zone using their postcode and state. Postcode and LGA boundaries don't always align, so the mapping is not exact. There are a number of postcodes that overlap multiple LGAs. The vast majority of postcodes sit within a single climate zone. There are far fewer postcodes that overlap multiple climate zones.

To map from postcode to climate zone, the count of dwellings by postcode and LGA from the Australian Bureau of Statistics (ABS) 2016 Census was used. For postcodes that overlap multiple climate zones, the postcode was allocated to the climate zone with the highest count of households. For example, consider a postcode that spanned three LGAs:

- LGA1, in Climate Zone 2. 30% of the households in the postcode
- LGA2, in Climate Zone 2. 30% of the households in the postcode
- LGA3, in Climate Zone 3. 40% of the households in the postcode.

This postcode would be mapped to Climate Zone 2, since 60% of households in that postcode are located in Climate Zone 2.

A small number of LGAs contain two climate zones, for example East Gippsland covers a wide area that includes Climate Zone 6 in the south and Climate Zone 7 in the north. For postcodes that map to these LGAs we made some manual refinements to the climate zone mapping to account for the postcode's location within the LGA.

### South Australian zones

The South Australian Minister for Energy and Mining requested that electricity consumption benchmarks for South Australia be based on localised zones using an extension of the National House Energy Rating Scheme (NaTHERS). These are the same zones that have been used for South Australia in the 2017, 2014, and 2011 benchmarks. There are ten such zones in South Australia, which are:

- Adelaide and environs
- Mount Lofty Ranges
- Central North
- Mid North
- Murraylands and Riverlands
- Yorke Peninsula and Kangaroo Island
- Port Augusta and pastoral
- West Coast
- Eastern Eyre
- South East.

## 3.2 Geographic regions for gas benchmarks

The AER is not required to develop residential gas consumption benchmarks and has discretion on the geographic basis on which to estimate gas consumption benchmarks. We were given guidance by the AER to adopt the approach used in the 2017 benchmarks to estimate gas consumption benchmarks for each State and Territory.

## 3.3 Survey data

In the ORU recruitment process, best attempts were made to recruit a diverse and representative group of participants. However, the composition of the sample is not entirely within ORU's control, particularly for a survey such as this which requires participants to opt-in, and to have sufficient information available to complete a survey on energy consumption. In this section we summarise the sample sizes used in the estimation of the electricity and gas benchmarks and provide summary statistics for the survey responses.

### 3.3.1 Sample sizes for electricity benchmarking dataset

Sample sizes within the final dataset used to estimate the electricity benchmarks, by climate zone, state, and household size are presented in **Table 2**.

**Table 2:** Summary of electricity dataset counts

| Climate zone | State / Territory | 1 person | 2 people | 3 people | 4 people | 5+ people | Total |
|---|---|---|---|---|---|---|---|
| 1 | QLD | 32 | 82 | 23 | 15 | 15 | **167** |
| 2 | NSW | 23 | 58 | 23 | 9 | 1 | **114** |
| 2 | QLD | 190 | 579 | 177 | 146 | 85 | **1,177** |
| 3 | QLD | 2 | 6 | 0 | 1 | 4 | **13** |
| 4 | NSW | 27 | 64 | 16 | 13 | 7 | **127** |
| 4 | SA | 4 | 7 | 2 | 3 | 2 | **18** |
| 4 | VIC | 12 | 27 | 2 | 4 | 8 | **53** |
| 5 | NSW | 230 | 652 | 201 | 163 | 93 | **1,339** |
| 5 | QLD | 12 | 25 | 9 | 11 | 7 | **64** |
| 5 | SA | 98 | 259 | 61 | 63 | 24 | **505** |
| 6 | NSW | 60 | 252 | 102 | 88 | 45 | **547** |
| 6 | SA | 13 | 50 | 9 | 9 | 6 | **87** |
| 6 | VIC | 259 | 684 | 221 | 215 | 95 | **1,474** |
| 7 | ACT | 32 | 111 | 25 | 19 | 16 | **203** |
| 7 | NSW | 11 | 30 | 13 | 9 | 5 | **68** |
| 7 | TAS | 61 | 160 | 52 | 46 | 23 | **342** |
| 7 | VIC | 24 | 90 | 17 | 25 | 11 | **167** |
| **Total** | **Total** | **1,090** | **3,136** | **953** | **839** | **447** | **6,465** |

*Source: Frontier Economics*

This shows that:

- The final sample size is 6,465 households
- The smallest sample size for a climate zone is in Climate Zone 3, with a sample of 13

- The largest samples came from Climate Zones 6 (which includes Melbourne), 5 (which includes Adelaide and Sydney), and 2 (which includes Brisbane).
- In some climate zones (such as 4, 5, and 7) the sample subset within some particular states is small, but the total across states is much larger.

Due to the small sample sizes in Climate Zone 3, we pooled households in Climate Zones 3 and 1 to develop electricity benchmarks. This is discussed further in Section 4 and Appendix B. For the remainder of this Section, we present summary statistics for the combined Climate Zones 1 and 3.

The number of responses in each sample group (combination of climate zone and household size) of **Table 2** is more important than the overall number of responses. High response counts produce benchmarks that are more precisely estimated than is possible with low counts.

The main reason for the low response counts in some combinations of climate zone and household size is low population. For example, far fewer people live in Climate Zone 3 (covering large areas of inland Queensland) than in Climate Zone 2 (which includes Brisbane), and fewer people live in households with 5 or more people than with 2 people. It is harder to recruit respondents in these smaller sample groups. Suggestions for potential improvements to the sampling methodology for future iterations of the benchmarking to address this problem are made in Section 6.

Due to the low response rate in some sample groups, it is necessary to 'pool' data to produce robust benchmark estimates. This involves combining sample groups, either across climate zones, states, or household sizes. A more detailed discussion of the pooling used to develop the benchmarks is provided in Appendix B.

### 3.3.2 Samples sizes for gas benchmarking dataset

Sample sizes in the final gas dataset used to estimate the gas benchmarks, by state and household size are presented in **Table 3**.

**Table 3:** Summary of gas dataset counts

| State / Territory | 1 person | 2 people | 3 people | 4 people | 5+ people | Total |
|---|---|---|---|---|---|---|
| ACT | 22 | 88 | 21 | 16 | 15 | **162** |
| NSW | 149 | 502 | 181 | 149 | 81 | **1,062** |
| QLD | 26 | 65 | 27 | 21 | 14 | **153** |
| SA | 66 | 192 | 49 | 48 | 18 | **373** |
| TAS | 5 | 10 | 2 | 1 | 0 | **18** |
| VIC | 213 | 644 | 212 | 219 | 92 | **1,380** |
| **Total** | **481** | **1,501** | **492** | **454** | **220** | **3,148** |

*Source: Frontier Economics*

This shows that:

- The final sample size is 3,148 households. This compares with a sample size of 2,518 households in the 2017 benchmarks
- The largest sample size for a jurisdiction is in Victoria, with a sample size of 1,380
- The smallest is in Tasmania with a sample size of only 18, reflecting the very low penetration of mains gas in that state.

Due to the small sample sizes in Tasmania, we pooled households in Tasmania and the ACT to develop gas benchmarks. This is discussed further in Section 5 and Appendix C. For the remainder of this section we present summary statistics for the combined ACT and Tasmania.

### 3.3.3 Descriptive statistics of the survey

This section provides descriptive summaries of the survey dataset.

#### Gender composition of sample

The gender mix of the survey sample is shown in **Table 4**.

**Table 4:** Gender composition of sample

| Gender | Sample | Population |
|---|---|---|
| Male | 56% | 49% |
| Female | 43% | 51% |
| Prefer to self describe / prefer not to say | <1% | N/A* |

*Source: Frontier Economics analysis of survey data, ABS data. *Note that the comparison ABS data presents sex, not gender, and categorises all people as male or female*

Overall, the survey sample has a higher proportion of males than the Australian population. The gender breakdown of the sample is similar to the 2017 sample. The reason for the gender imbalance isn't clear as our understanding is that the ORU panel is representatively balanced between males and females. It is important to note that there is an element of self-selection in the survey responses. Respondents must consent to participate, must be able to find their NMI from a recent bill, and must have sufficient interest to do these things and complete the survey.

### Age composition of sample

The age composition of the survey sample is shown in **Table 5**.

**Table 5:** Age composition of sample

| Age bracket | Sample | Population* |
|---|---|---|
| 18-29 | 5% | 22% |
| 30-49 | 26% | 35% |
| 50-64 | 32% | 23% |
| 65+ | 37% | 20% |

*Source: Frontier Economics analysis of survey data, ABS data. *Note that the ABS population values reflect all people in the household, while the sample reflects the survey respondent who may not be representative of the household overall. The survey was only available to people aged 18 or above, therefore the population proportions are also based on people aged 18 or above.*

The 2017 benchmarking study collected the age of all people in the household, in addition to that of the survey respondent. It found that, although survey respondents were over-represented in higher age brackets and under-represented in lower age brackets, the age composition of all members of the household was in line with the population. For this study, the age composition of all people in the household was not collected, so this comparison cannot be made. The likely reason for the imbalance between the ages of the sample respondents and of the population is that sample respondents are people in the household who have access to the energy bills, and hence are likely to be older.

### Household size composition of sample

The composition of household sizes in the sample and the population is presented in **Table 6**. The sample is broadly in line with the population, although it has a higher proportion of two person households, and a lower proportion of all other household. Benchmarks are estimated for each household size so if there is a difference in energy consumption for different household sizes this is directly accounted for in the benchmarks.

**Table 6:** Household size composition of sample

| Number of people | Sample | Population |
|---|---|---|
| 1 | 17% | 24% |
| 2 | 49% | 33% |
| 3 | 15% | 16% |
| 4 | 13% | 16% |
| 5+ | 7% | 10% |

*Source: Frontier Economics analysis of survey data, ABS data*

### Solar PV composition of sample

The proportion of households in the sample with solar PV is presented in **Table 7**. Households with solar PV are considerably over-represented in the sample in every jurisdiction. It isn't clear why this is the case. It is worth noting that households with solar PV were also over-represented in the 2017 benchmarking sample. There are several potential factors that could contribute.

**Table 7:** Solar PV composition of sample

| State / Territory | Sample | Population |
|---|---|---|
| ACT | 31% | 15% |
| NSW | 27% | 17% |
| QLD | 47% | 33% |
| SA | 53% | 34% |
| TAS | 31% | 15% |
| VIC | 29% | 17% |

*Source: Frontier Economics analysis of survey data, CER data, AER RIN data*

Firstly, due to the nature of the consumption benchmarks the survey was available to people who had lived in their house for longer than 18 months. Homeowners are more likely to have lived in their house for 18 months than renters, and are also more likely to have solar PV than renters. This could explain some proportion of the over-representation.

Secondly, it is possible that the ORU panel is constructed in some manner that introduces the over-representation of households with solar PV. However we are not aware of any clear evidence suggesting that this is the case. The 2017 benchmarking sample was not constructed using the ORU panel and a similar phenomenon arose.

Finally, as outlined above, it is important to consider that there is an element of self-selection in the survey responses. It is possible that households with solar PV are, for whatever reason, more likely than other households to complete the survey. For example, they may be more engaged with their household energy use and therefore more likely to locate their NMI and complete a survey about household energy consumption.

Solar PV panels have an impact on energy consumption. If households in each state with solar PV consume less electricity from the grid than households without, then the sample would potentially provide a biased estimate of average electricity consumption. Therefore, it is important to use some form of weighting to address the difference in solar PV in the sample compared to the population. Our approach to addressing any potential impact from the over-representation of solar households is presented in Section 4.1.

### Gas connected composition of sample

**Table 8** presents the composition of households with mains gas in the sample

**Table 8:** Mains gas composition of sample

| State / Territory | Sample | Population |
| --- | --- | --- |
| ACT | 78% | 70% |
| NSW | 47% | 44% |
| QLD | 12% | 10% |
| SA | 62% | 56% |
| TAS | 8% | 4% |
| VIC | 82% | 77% |

*Source: Frontier Economics analysis of survey data, AER data, gas network Access Arrangements*

Overall, the proportion of households with mains gas in the sample is similar to the estimates for the population which are based on mains gas customer numbers reported in Access Arrangements, the AER's State of the Energy Market report,[8] and company websites. There appears to be a minor over-representation in the sample of households with mains gas in most regions. Tasmania may appear to have a larger over-representation of gas households. However, the number of gas households in Tasmania in the sample is low (27), and the population estimate

[8] Australian Energy Regulator, 2020, *State of the Energy Market 2020*, https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2020

is quite uncertain as TasGas is not regulated by the AER and not required to regularly publish audited customer numbers.

Like solar PV, having a mains gas connection has an impact on energy consumption. Gas is a potential alternative to electricity for certain major uses such as space heating, water heating and cooking. All else being equal, a household with a gas connection is likely to use less electricity than a similar household with no gas connection. Therefore, as for solar PV, it is important to use some form of weighting to address the over-representation of mains gas households in the sample compared to the population. Our approach is presented in Section 4.1.

## 3.4 Electricity consumption data

The average seasonal electricity consumption for households in the dataset is presented in **Table 9** below.

**Table 9:** Average electricity consumption by DNSP (kilowatt hours, kWh)

| State | DNSP | Count | Summer | Autumn | Winter | Spring | Annual |
|---|---|---|---|---|---|---|---|
| ACT | EvoEnergy | 203 | 1,258 | 1,550 | 2,168 | 1,431 | 6,407 |
| NSW | Ausgrid | 1,245 | 1,360 | 1,283 | 1,679 | 1,207 | 5,529 |
| NSW | Endeavour | 534 | 1,512 | 1,403 | 1,726 | 1,340 | 5,981 |
| NSW | Essential | 416 | 1,291 | 1,307 | 1,639 | 1,240 | 5,477 |
| QLD | Energex | 1,062 | 1,513 | 1,380 | 1,324 | 1,264 | 5,481 |
| QLD | Ergon | 359 | 1,562 | 1,408 | 1,328 | 1,290 | 5,588 |
| SA | SAPN | 610 | 1,181 | 1,190 | 1,465 | 1,114 | 4,950 |
| TAS | TasNetworks | 342 | 1,536 | 2,049 | 2,915 | 2,119 | 8,619 |
| VIC | Ausnet | 426 | 1,200 | 1,149 | 1,572 | 1,102 | 5,023 |
| VIC | Citipower | 235 | 983 | 999 | 1,394 | 974 | 4,350 |
| VIC | Jemena | 174 | 951 | 987 | 1,383 | 958 | 4,279 |
| VIC | Powercor | 357 | 1,134 | 1,124 | 1,531 | 1,090 | 4,879 |
| VIC | United | 502 | 1,065 | 1,062 | 1,387 | 1,030 | 4,544 |

*Source: Frontier Economics analysis of AEMO and DNSP data*

Customers from TasNetworks have the highest electricity consumption overall, and the highest in all seasons except for summer. Tasmania displays a clear seasonality, with average winter consumption close to double the average summer consumption.

Households in the ACT, and all of the New South Wales networks, also have their highest seasonal consumption in winter. However, overall consumption is not as high as Tasmania, and the degree of seasonality is not as great as Tasmania. Customers from EvoEnergy in the ACT have the second highest annual consumption on average.

In the Queensland networks of Energex and Ergon, average seasonal consumption is similar overall to the New South Wales networks. However, these networks have highest seasonal consumption in summer, and the lowest in winter and spring.

Average consumption in South Australia and the Victorian networks is the highest in winter, and similar in other seasons. Average consumption is the lowest in Citipower and Jemena's network areas, at approximately half that of TasNetworks' customers on average.

**Table 10** presents a summary of annual electricity consumption by climate zone and energy service type (i.e. whether the households have controlled load (CL), solar PV, or mains gas).

**Table 10:** Average electricity consumption by sample subsets (kWh per annum)

| Climate zone | Count | All | CL | No CL | Solar PV | No solar PV | Gas | No gas |
|---|---|---|---|---|---|---|---|---|
| CZ 1 and 3 | 180 | 5,977 | 6,317 | 5,116 | 5,784 | 6,128 | 5,265 | 6,243 |
| CZ 2 | 1,291 | 5,341 | 5,847 | 4,602 | 5,137 | 5,529 | 5,192 | 5,423 |
| CZ 4 | 198 | 6,258 | 6,932 | 5,324 | 5,619 | 6,748 | 6,173 | 6,430 |
| CZ 5 | 1,908 | 5,154 | 6,426 | 4,330 | 5,089 | 5,181 | 4,805 | 5,787 |
| CZ 6 | 2,108 | 4,953 | 6,400 | 4,435 | 4,605 | 5,105 | 4,672 | 6,171 |
| CZ 7 | 780 | 7,229 | 8,267 | 6,955 | 6,974 | 7,355 | 6,225 | 8,336 |

*Source: Frontier Economics analysis of AEMO and DNSP data*

The average annual consumption of households is the highest in Climate Zone 7, with 7,229 kWh per year. Climate Zone 7 includes ACT, Tasmania, alpine New South Wales and alpine Victoria with cold winters. Consumption is the lowest in the cool temperate Climate Zone 6 which includes Melbourne (and also has a high penetration and consumption of mains gas).

On average, households with controlled load consume more than households without controlled load in every climate zone. The difference between the two is typically in the order of 25%-45%. Households with solar PV consume less electricity from the grid on average than households without in every climate, typically about 5%-15% less. It is important to note that this refers only to electricity consumed from the grid, and does not account for self-consumption of electricity generated by their solar PV which they are not charged for by the retailer.

Households with mains gas consume less electricity than households without in each climate zone. The biggest differences are in the cooler Climate Zones 6 and 7 which have the largest heating requirements, where the difference is approximately 25%.

## 3.5 Gas consumption data

**Table 11:** Average seasonal gas consumption by state (megajoules, MJ)

| State | Count | Summer | Autumn | Winter | Spring | Annual |
|---|---|---|---|---|---|---|
| ACT and TAS | 180 | 2,316 | 8,029 | 16,729 | 7,853 | 34,927 |
| NSW | 1,062 | 2,533 | 4,237 | 7,339 | 4,275 | 18,384 |
| QLD | 153 | 1,262 | 1,694 | 2,519 | 1,763 | 7,238 |
| SA | 373 | 2,036 | 3,681 | 6,534 | 3,948 | 16,199 |
| VIC | 1,380 | 3,999 | 10,091 | 23,435 | 12,274 | 49,799 |

*Source: Frontier Economics analysis of gas network data*

In all regions, average gas consumption is the highest in winter, and lowest in summer. Autumn and spring are similar in most regions and sit in between.

Victoria has the highest average consumption of approximately 49,799MJ per annum. The highest season is winter, at 23,435MJ and lowest is summer at 3,999MJ. The ACT and Tasmania have the second highest, but both sit considerably behind Victoria. Gas consumption is the lowest in Queensland with average consumption of 7,238MJ per year.

Gas consumption in the cooler regions of ACT, Tasmania and Victoria is highly seasonal, with winter consumption making up approximately 47% of annual consumption. In New South Wales and South Australia winter consumption makes up approximately 40% of annual consumption, and in warmer Queensland it makes up approximately 35%.

A summary of gas consumption by jurisdiction, split by households with and without major end-uses of gas, is presented in **Table 12** below.

**Table 12:** Average gas consumption by sample subsets (MJ per annum)

| State | All | Space heating | No space heating | Water heating | No water heating | Cooking | No cooking |
|---|---|---|---|---|---|---|---|
| ACT and TAS | 34,927 | 47,986 | 15,195 | 33,324 | 35,260 | 32,341 | 37,164 |
| NSW | 18,384 | 25,007 | 14,049 | 19,407 | 15,052 | 17,581 | 20,991 |
| QLD | 7,238 | 10,329 | 6,903 | 7,919 | 3,772 | 7,410 | 5,887 |
| SA | 16,199 | 26,593 | 11,781 | 16,266 | 14,331 | 15,831 | 16,073 |
| VIC | 49,799 | 57,757 | 32,935 | 51,871 | 42,564 | 48,843 | 51,074 |

*Source: Frontier Economics analysis of gas network data*

In all regions, households that use gas for space heating consume considerably more gas than households that don't. The relative difference is the highest in the ACT and Tasmania, which experience cold winters. In these jurisdictions, households that use gas for space heating consume approximately three times as much gas as those that don't. The difference is the lowest in absolute and relative terms in Queensland, which has a warmer climate.

In most regions, households that use gas for water heating consume more gas than households that don't. However in the ACT, households that don't use gas for water heating consume slightly more gas on average than households that do.

There isn't a clear relationship overall in gas consumption for households that do and do not use it for cooking. The amount of energy used for cooking is generally lower than for space heating and water heating and is therefore less influential in determining average gas consumption.

# 4 Electricity consumption benchmarks

This section sets out the approach used to estimate the electricity consumption benchmarks, and presents a summary of the benchmarks in each localised zone.

## 4.1 Summary of approach

### 4.1.1 Purpose and structure of electricity consumption benchmarks

The purpose of the electricity benchmarks is to allow residential consumers to compare their usage with similar households in their area. This in turn assists consumers to make more informed choices about how they use energy.

As agreed with the AER, a single consumption benchmark is produced for each household size in each region. This simple benchmark captures the key drivers of consumption, but is not intended to capture all relevant drivers. Hence, households may have electricity consumption materially above or below the benchmarks for a range of reasons.

The 2017 benchmarks were also estimated by household size and region, but with one additional 'benchmark factor' found to be useful for explaining electricity consumption in the climate zone. In warmer climate zones, the benchmark factor was whether the dwelling had a swimming pool. In cooler zones, the benchmark factor was whether the dwelling had a mains gas connection or whether it had electric underfloor slab heating. For each zone and household size, retailers would then select the consumption benchmark to use to display on each bill, i.e. the benchmark 'with' the benchmark factor or the benchmark 'without' the benchmark factor.

However, retailers typically do not have the information on customers required to determine which benchmark to use (i.e. with or without the benchmark factor). Some, but not all, retailers may know that a household has a mains gas connection if it is also the gas retailer for that household. In general, a retailer could not observe whether a household has a pool or slab heating.

As a result, retailers tended to select one of the two benchmarks, and display that benchmark on all bills in the region. This would typically be the benchmark 'without' the factor (e.g. a dwelling without a pool, or without a mains gas connection, or without slab heating) as this applied to the majority of households in the region. Households 'with' the factor could find the relevant benchmarks for their household through the Energy Made Easy (EME) website.

Therefore, for the 2020 benchmarks a single consumption benchmark is produced for each household size in each region – with no benchmark factor. This removes the requirement on retailers to make a judgement on the most suitable consumption benchmark to display on bills. There are different approaches to incorporating benchmarks which could be considered in future iterations of the benchmarking exercise. These are discussed further in Section 6.

### 4.1.2 Model selection and weighting the sample

The electricity consumption benchmarks for each climate zone do not include any explanatory benchmark factors other than household size. However, the benchmark models prepared for 2020 enable additional factors to be considered for broader purposes, such as more detailed consumption benchmarks for the EME website.

As outlined in Section 3, the sample size in Climate Zone 3 is small (at 13 households). This is too small to independently estimate benchmarks. We pooled the households in Climate Zone 3 with Climate Zone 1, which is the closest geographically and has the most similar climate. This ensured a minimum sample size of at least 15 for each household size.

A number of climate zones cross multiple jurisdictions – for example, Climate Zone 4 crosses South Australia, New South Wales and Victoria. In these climate zones it is possible to estimate a separate set of benchmarks for each climate zone / jurisdiction combination or to pool households of the same size across jurisdictions. At times pooling is useful to improve the statistical properties of the estimated benchmarks.

In general, the starting point for each climate zone was to estimate a model that included all households within the climate zone, but with separate dummy variables[9] for each household size within each state. For example for Climate Zone 4 this starting model would include 15 variables (household sizes 1-5+ in South Australia, 1-5+ in New South Wales, and 1-5+ in Victoria). We also considered 'pooled' models that combined households from different jurisdictions within the climate zone and estimated common benchmarks for each household size.

In some cases there are 'backwards steps' in electricity consumption, where average consumption is lower for a larger household size than a smaller one. This is not necessarily implausible. There are a number of drivers of household electricity consumption, the number of people in the dwelling being just one of these. However such backward steps would be confusing for retail customers. In cases when backward steps occurred, we tested statistically whether it would be reasonable to pool household sizes to avoid backwards steps and pooled the household sizes when this was statistically justified.

A number of different models were tested within each climate zone with different pooling options between jurisdictions and household sizes. A preferred model was selected from the alternative models estimated. This necessarily involved some professional judgement; however, we were guided by a number of criteria, such as:

- Maximising the explanatory power of the model according to a number of statistical criteria
- Reducing the number of backwards steps by pooling across jurisdictions and/or household sizes where possible.

As discussed in Section 3.3.3, the sample is overrepresented with respect to households with solar PV, and slightly overrepresented with respect to households with mains gas. This potentially poses an issue for the consumption benchmarks if households with solar PV or with mains gas tend to consume a different level of electricity than households without.

[9] A dummy variable takes the value of 0 or 1 and is used to indicate whether an observation is part of a category or not. For example, a dummy variable for '4 person household' would take the value '1' for households with 4 people, and 0 for all other households.

Therefore we included a dummy variable for solar PV and for mains gas in the consumption benchmark models. We evaluated the models at the jurisdictional average proportions of households with solar PV and mains gas.

This approach to reweighting for solar PV and mains gas is done at a jurisdictional level. Therefore, where a model for a particular climate zone is pooled across jurisdictions, different benchmarks are estimated due to jurisdiction specific weighting for solar PV and mains gas

Further information on the model selection and weighting process is provided in in Appendix B.

### 4.1.3 South Australian benchmarks

As outlined in Section 3.1, the South Australian Minister for Energy and Mining requested that South Australian electricity consumption benchmarks be based on an extension of the NaTHers climate zones. These are a different set of localised zones compared to the zones for other jurisdictions which were based on ABCB climate zones.

To estimate the South Australian electricity consumption benchmarks, the approach from the 2017 benchmarking exercise was followed. Essentially this involves taking the climate zone benchmarks in South Australia (Climate Zones 4, 5, 6) and applying a weighted average of these to estimate benchmarks for the South Australian zones that sit within or across each climate zone. This is necessary due to the small population in most of the South Australian localised zones, which cannot support large enough sample sizes to estimate the localised zone benchmarks directly. This approach was agreed with the AER.

For example, consider the SA zone 'South East'. This zone sits entirely within the Climate Zone 6. Therefore the SA 'South East' benchmarks are based on a 100% weighting of the Climate Zone 6 benchmarks.

Alternatively, consider the SA zone 'Port Augusta and Pastoral'. This spans Climate Zones 4, 5 and 6, with 76% of households in the population sitting in Climate Zone 4, 15% in Climate Zone 5 and the remaining 8% in Climate Zone 6.[10] Therefore the SA 'Port Augusta and Pastoral' benchmarks are calculated using a weighted average of the benchmarks for the three climate zones, with the split of households between climate zones used as weights.

## 4.2 Summary of results

### 4.2.1 Climate Zones 1 and 3

The sample includes 167 households in Climate Zone 1, which covers a large area of far North Queensland. Much of Climate Zone 1 is neighboured by Climate Zone 3, which covers a vast but sparsely populated area of inland Queensland. The sample contained only 13 respondents from Climate Zone 3.

Climate Zones 1 and 3 were pooled in the same model and a single set of combined benchmarks estimated for the two climate zones. In summer, 4 and 5 person households were also pooled. Further information on the benchmark model for Climate Zones 1 and 3 is set out in Appendix B.

The consumption benchmarks for Climate Zone 1 are presented in **Table 13** and **Figure 2**.

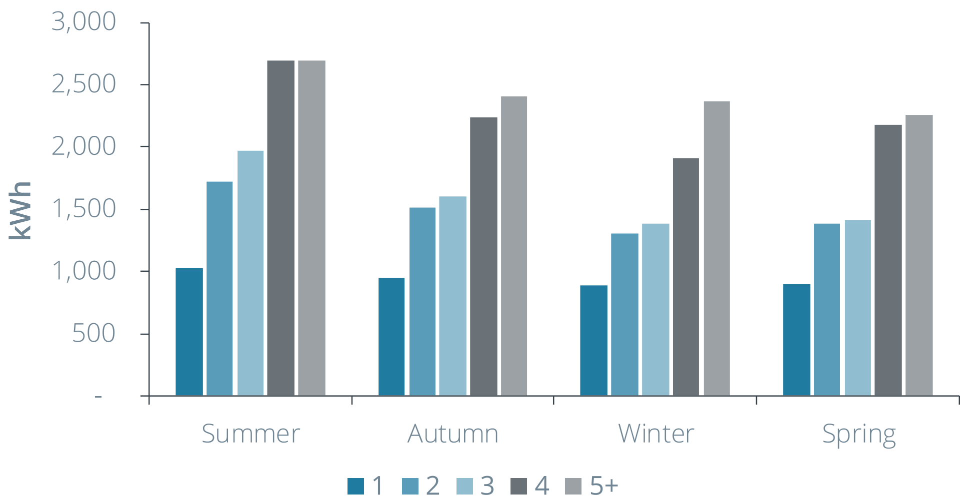
[10] The population dwelling counts by postcode and LGA were taken from the ABS 2016 Census.

**Table 13:** Climate Zones 1 and 3: Consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| QLD | 1 | 1,029 | 948 | 887 | 895 |
| QLD | 2 | 1,721 | 1,516 | 1,309 | 1,387 |
| QLD | 3 | 1,973 | 1,603 | 1,388 | 1,412 |
| QLD | 4 | 2,690 | 2,237 | 1,914 | 2,178 |
| QLD | 5+ | 2,690 | 2,404 | 2,365 | 2,256 |

*Source: Frontier Economics*

**Figure 2**: Climate Zones 1 and 3: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

Overall, electricity consumption in the pooled Climate Zones 1 and 3 is highest in summer and lowest in winter. This is in line with expectations given the warm conditions in these climate zones. Consumption in autumn and spring are similar and sit between summer and winter. The summer benchmark in Climate Zones 1 and 3 is the highest of any climate zone in that season, and the winter benchmark is close to the lowest along with Climate Zone 2.

A depiction of average seasonal consumption by household size in Climate Zones 1 and 3, including the consumption benchmarks, is presented in **Figure 24** in Appendix E.

### 4.2.2 Climate Zone 2

The sample includes 1,291 households in Climate Zone 2. The majority of these (1,177 households) are in Queensland. Climate Zone 2 includes several major urban centres in

Queensland including Brisbane and the Gold Coast. The remaining 114 households are in northern New South Wales.

Households from Queensland and New South Wales were pooled in the same model to develop the benchmarks for Climate Zone 2. Further information on the benchmark model for Climate Zone 2 is set out in Appendix B.

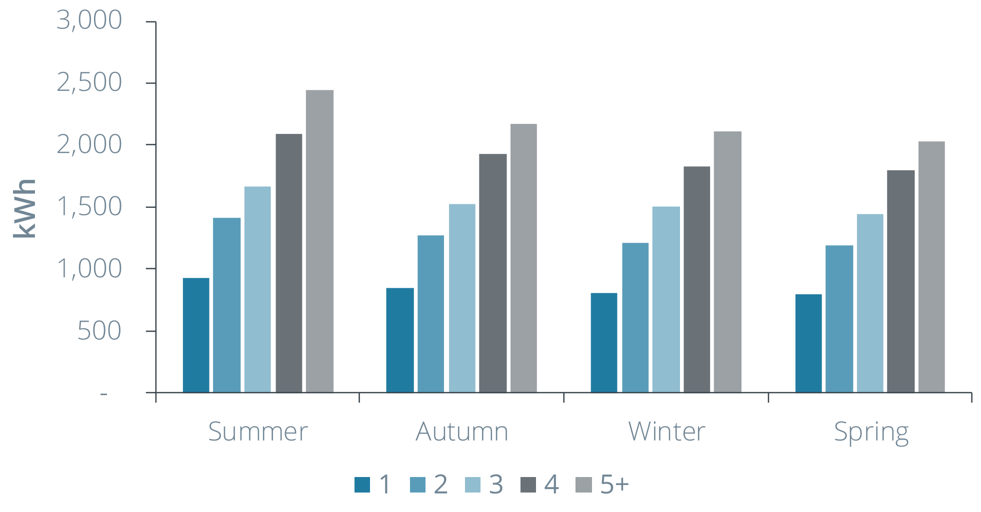
The consumption benchmarks for Climate Zone 2 are presented in **Table 14**, **Figure 3**, and **Figure 4**.

**Table 14:** Climate Zone 2: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| NSW | 1 | 926 | 847 | 805 | 793 |
| NSW | 2 | 1,412 | 1,271 | 1,208 | 1,195 |
| NSW | 3 | 1,662 | 1,520 | 1,502 | 1,442 |
| NSW | 4 | 2,093 | 1,925 | 1,830 | 1,793 |
| NSW | 5+ | 2,448 | 2,172 | 2,111 | 2,032 |
| QLD | 1 | 908 | 857 | 848 | 799 |
| QLD | 2 | 1,393 | 1,281 | 1,250 | 1,202 |
| QLD | 3 | 1,644 | 1,531 | 1,545 | 1,449 |
| QLD | 4 | 2,074 | 1,935 | 1,873 | 1,800 |
| QLD | 5+ | 2,430 | 2,182 | 2,153 | 2,038 |

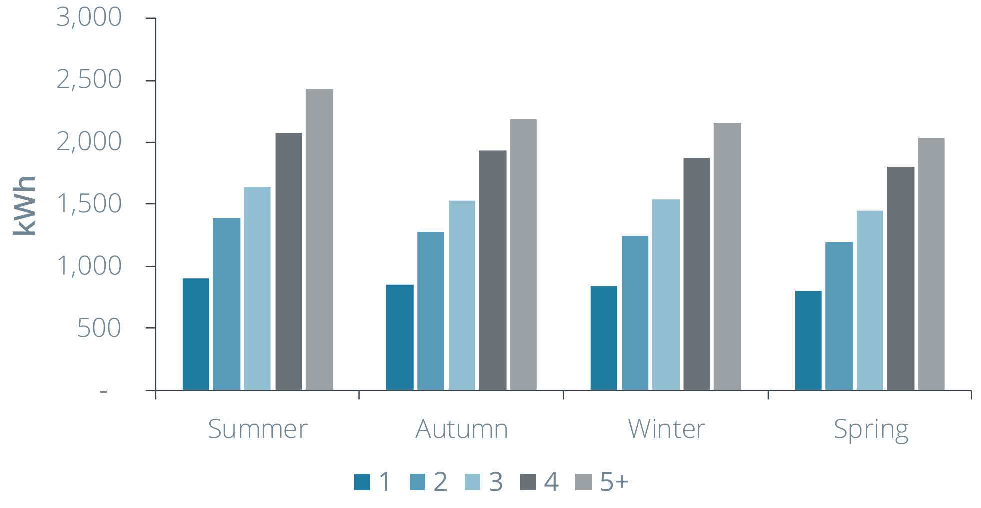
*Source: Frontier Economics*

**Figure 3**: NSW Climate Zone 2: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

**Figure 4**: QLD Climate Zone 2: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

Overall, electricity consumption in Climate Zone 2 is highest in summer and lowest in winter and spring. Like Climate Zone 1, this is broadly expected based on the warm climate in the zone. However, the difference between the seasons is not as pronounced as in some other regions. The difference between the highest seasonal consumption (summer) and the lowest (winter) is the smallest of any climate zone.

For Queensland, consumption in Climate Zone 2 is approximately 10% lower than in Climate Zones 1 and 3. The main difference between the zones is in summer, with winter electricity consumption more similar.

In Climate Zone 2, average electricity consumption increases steadily with the number of people in the dwelling.

A depiction of average seasonal consumption by household size and state in Climate Zone 2, including the electricity consumption benchmarks, is presented in **Figure 25** in Appendix E.

### 4.2.3 Climate Zone 4

The sample includes 198 households in Climate Zone 4. The majority of these (127 households) are in New South Wales, with 53 in Victoria and 18 in South Australia. Climate Zone 4 covers a wide and sparsely populated region across north west Victoria and New South Wales and northern South Australia.

Households from New South Wales, South Australia, and Victoria were pooled in the same model to develop the benchmarks for Climate Zone 4. We also pooled households with 3, 4, and 5+ people in all seasons. Further information on the benchmark model for Climate Zone 4 is set out in Appendix B.

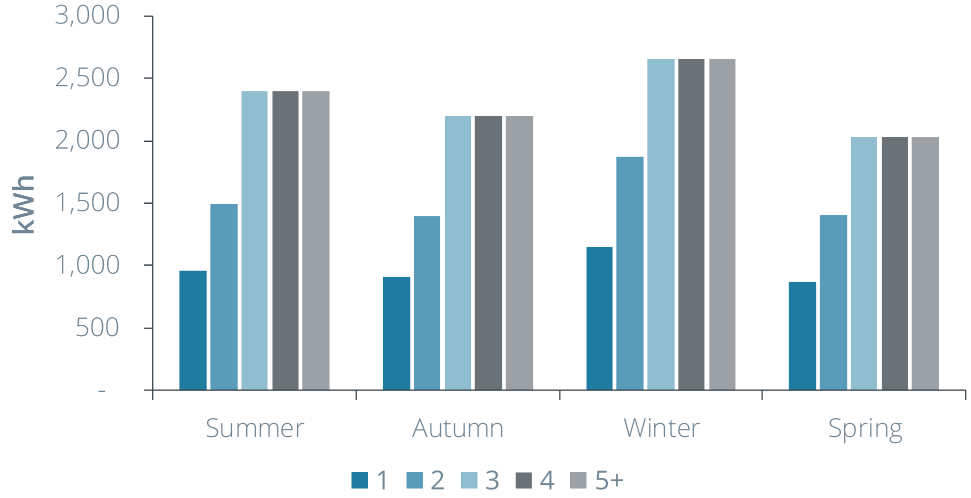
The electricity consumption benchmarks for Climate Zone 4 are presented in **Table 15**, **Figure 5**, **Figure 6**, and **Figure 7**.

**Table 15:** Climate Zone 4: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| NSW | 1 | 957 | 909 | 1,153 | 871 |
| NSW | 2 | 1,492 | 1,393 | 1,870 | 1,406 |
| NSW | 3 | 2,401 | 2,202 | 2,658 | 2,034 |
| NSW | 4 | 2,401 | 2,202 | 2,658 | 2,034 |
| NSW | 5+ | 2,401 | 2,202 | 2,658 | 2,034 |
| SA | 1 | 937 | 858 | 1,116 | 790 |
| SA | 2 | 1,472 | 1,342 | 1,833 | 1,326 |
| SA | 3 | 2,381 | 2,152 | 2,621 | 1,953 |
| SA | 4 | 2,381 | 2,152 | 2,621 | 1,953 |
| SA | 5+ | 2,381 | 2,152 | 2,621 | 1,953 |
| VIC | 1 | 1,052 | 930 | 1,062 | 871 |
| VIC | 2 | 1,586 | 1,414 | 1,779 | 1,406 |
| VIC | 3 | 2,495 | 2,223 | 2,567 | 2,034 |
| VIC | 4 | 2,495 | 2,223 | 2,567 | 2,034 |
| VIC | 5+ | 2,495 | 2,223 | 2,567 | 2,034 |

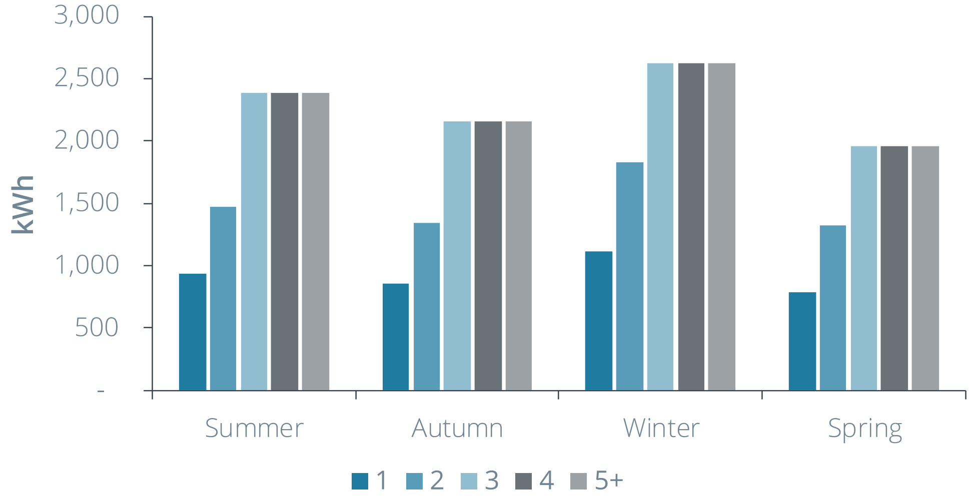
*Source: Frontier Economics*

**Figure 5**: NSW Climate Zone 4: Electricity consumption benchmarks by household size



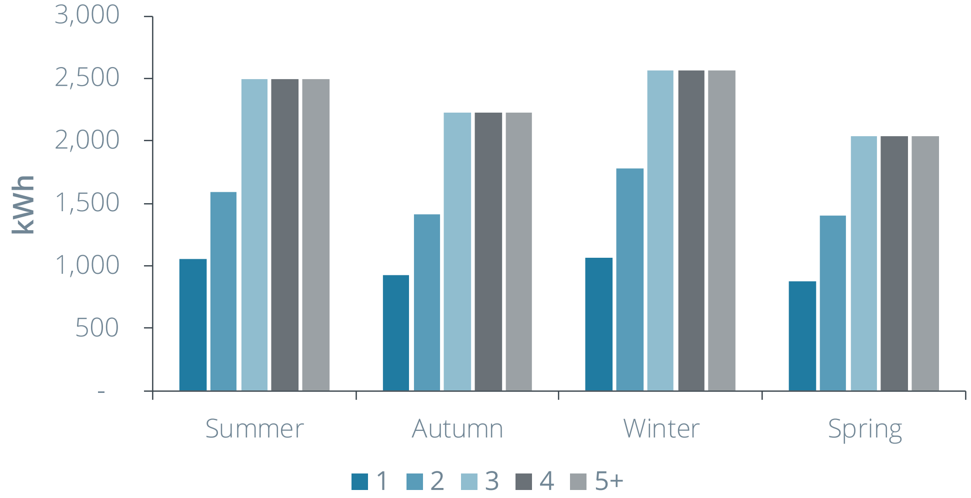

*Source: Frontier Economics*

**Figure 6**: SA Climate Zone 4: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

**Figure 7**: VIC Climate Zone 4: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

Climate Zone 4 is characterised by hot dry summers and cool winters. Overall, electricity consumption is highest in winter, followed by summer and autumn, with consumption the lowest in spring. Climate Zone 4 has high electricity requirements, with the average consumption across all seasons the second highest of all climate zones.

Electricity consumption is similar for households with 3 or more people, supporting the pooling of those household sizes.

A depiction of average seasonal consumption by household size and state in Climate Zone 4, including the electricity consumption benchmarks, is presented in **Figure 26** in Appendix E.

### 4.2.4 Climate Zone 5

The sample includes 1,908 households in Climate Zone 5. This includes 1,339 in New South Wales and 505 in South Australia. Climate Zone 5 covers several metropolitan areas including greater Sydney and Adelaide. The remaining 64 are in Queensland, in a small pocket to the immediate west of Brisbane.

Households from Queensland and New South Wales were pooled in the same model to develop the benchmarks for Climate Zone 5. Further information on the benchmark model for Climate Zone 5 is set out in Appendix B.

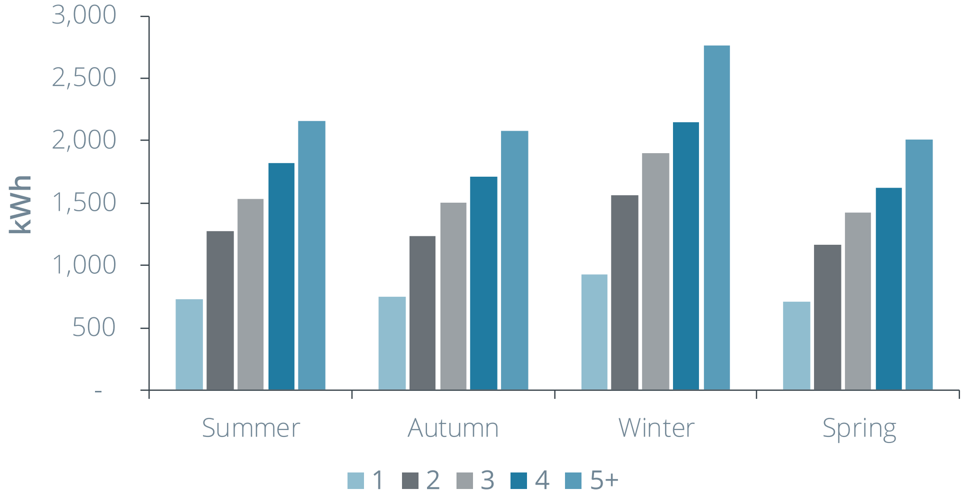
The electricity consumption benchmarks for Climate Zone 5 are presented in **Table 16**, **Figure 8**, **Figure 9**, and **Figure 10**.

**Table 16:** Climate Zone 5: Electricity consumption benchmarks by household size (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| NSW | 1 | 732 | 745 | 927 | 705 |
| NSW | 2 | 1,278 | 1,232 | 1,565 | 1,162 |
| NSW | 3 | 1,530 | 1,503 | 1,903 | 1,425 |
| NSW | 4 | 1,819 | 1,717 | 2,148 | 1,627 |
| NSW | 5+ | 2,158 | 2,082 | 2,761 | 2,007 |
| QLD | 1 | 787 | 825 | 1,076 | 775 |
| QLD | 2 | 1,333 | 1,312 | 1,714 | 1,232 |
| QLD | 3 | 1,585 | 1,584 | 2,051 | 1,495 |
| QLD | 4 | 1,874 | 1,797 | 2,297 | 1,696 |
| QLD | 5+ | 2,212 | 2,163 | 2,910 | 2,076 |
| SA | 1 | 689 | 702 | 882 | 646 |
| SA | 2 | 1,234 | 1,190 | 1,520 | 1,103 |
| SA | 3 | 1,486 | 1,461 | 1,858 | 1,366 |
| SA | 4 | 1,776 | 1,674 | 2,103 | 1,568 |
| SA | 5+ | 2,114 | 2,040 | 2,716 | 1,948 |

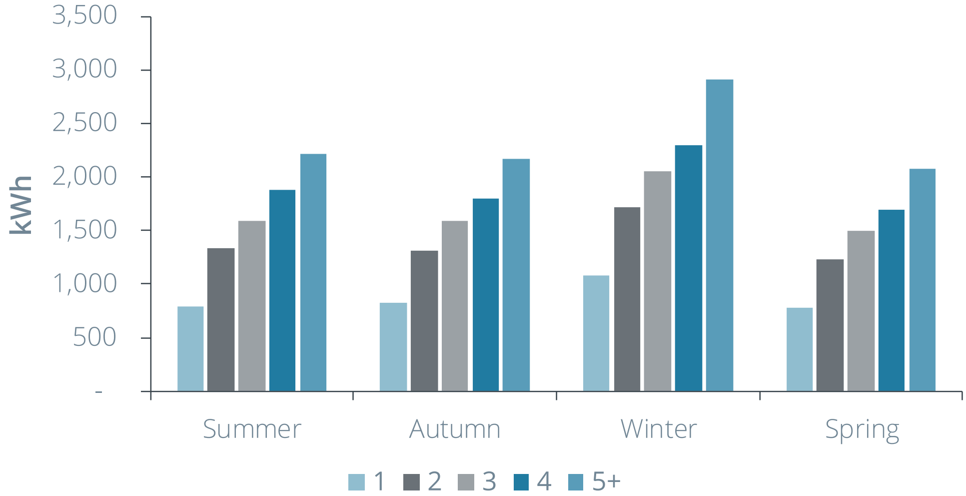
*Source: Frontier Economics*

**Figure 8**: NSW Climate Zone 5: Electricity consumption benchmarks by household size



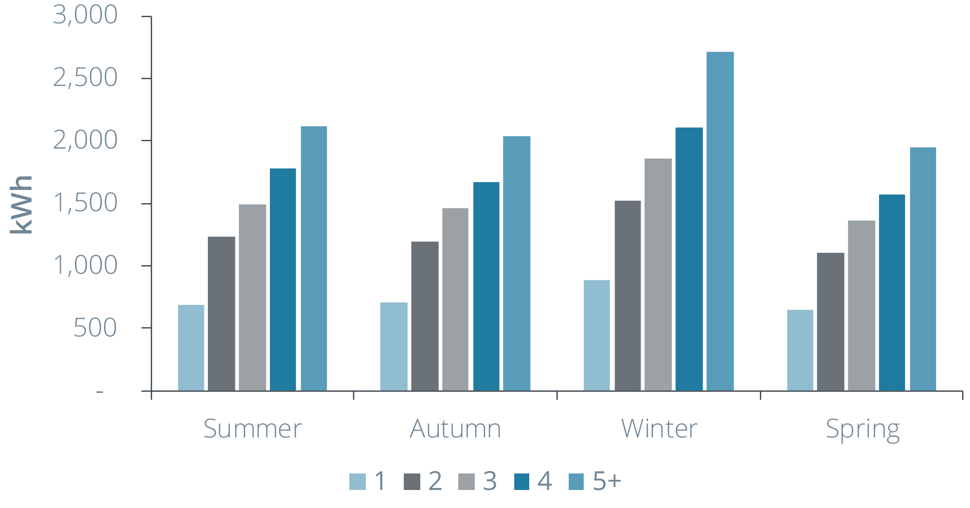

*Source: Frontier Economics*

**Figure 9**: QLD Climate Zone 5: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

**Figure 10**: SA Climate Zone 5: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

Climate Zone 5 is described as warm but temperate. Electricity consumption is highest in winter, followed by summer and autumn, with consumption the lowest in spring. This is the same pattern as Climate Zones 6 and 4 which tend to neighbour it in its most populous areas, around Sydney and Adelaide. Climate Zone 5 has demand for both cooling in summer, and heating in winter, but doesn't have the same level of gas penetration to support the winter load as some of the cooler parts of the country.

Average electricity consumption over the year in Climate Zone 5 is quite similar to Climate Zone 2, but with a redistribution from summer to winter. Average electricity consumption increases steadily by household size in all states.

A depiction of average seasonal consumption by household size and state in Climate Zone 5, including the electricity consumption benchmarks, is presented in **Figure 27** in Appendix E.

### 4.2.5 Climate Zone 6

The sample includes 2,108 households in Climate Zone 6, which is the highest amount in any climate zone. Of these, 1,474 are in Victoria, with Climate Zone 6 covering metropolitan Melbourne as well as a number of large regional centres. A further 547 are in New South Wales, and the remaining 87 are in South Australia.

While households in South Australia and Victoria were pooled, separate models for households in New South Wales were estimated. The 3 and 4 person households in New South Wales were pooled in summer. Further information on the benchmark model for Climate Zone 6 is set out in Appendix B.

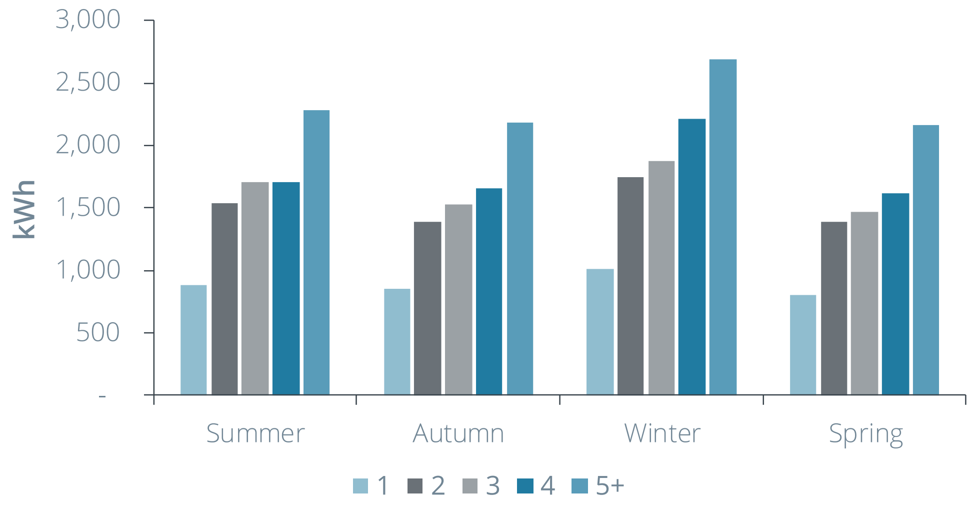
The electricity consumption benchmarks for Climate Zone 6 are presented in **Table 17**, **Figure 11**, **Figure 12**, and **Figure 13**.

**Table 17:** Climate Zone 6: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| NSW | 1 | 883 | 848 | 1,010 | 800 |
| NSW | 2 | 1,535 | 1,385 | 1,752 | 1,388 |
| NSW | 3 | 1,703 | 1,528 | 1,874 | 1,465 |
| NSW | 4 | 1,703 | 1,656 | 2,213 | 1,622 |
| NSW | 5+ | 2,285 | 2,184 | 2,690 | 2,161 |
| SA | 1 | 673 | 730 | 1,035 | 709 |
| SA | 2 | 1,110 | 1,171 | 1,600 | 1,151 |
| SA | 3 | 1,142 | 1,211 | 1,713 | 1,204 |
| SA | 4 | 1,322 | 1,384 | 1,929 | 1,363 |
| SA | 5+ | 1,685 | 1,764 | 2,352 | 1,743 |
| VIC | 1 | 674 | 684 | 927 | 668 |
| VIC | 2 | 1,112 | 1,125 | 1,493 | 1,110 |
| VIC | 3 | 1,143 | 1,165 | 1,606 | 1,163 |
| VIC | 4 | 1,324 | 1,338 | 1,821 | 1,322 |
| VIC | 5+ | 1,686 | 1,718 | 2,245 | 1,702 |

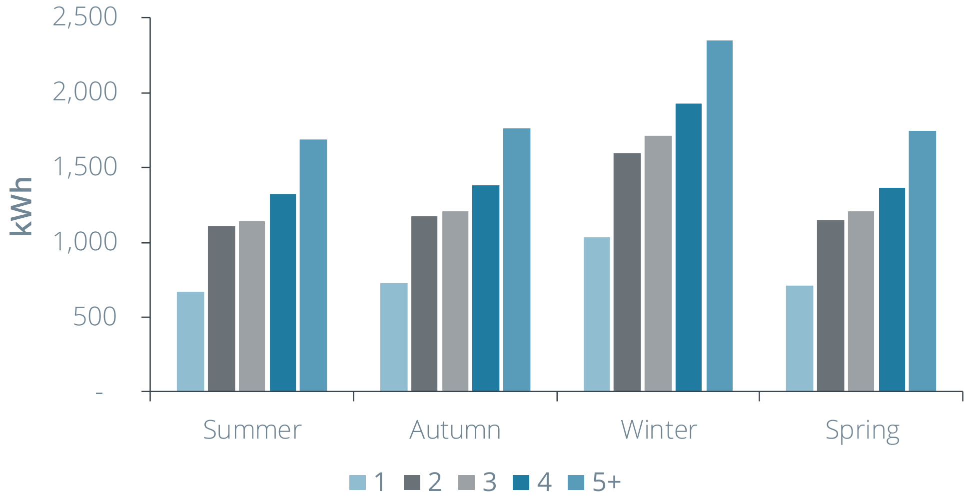
*Source: Frontier Economics*

**Figure 11**: NSW Climate Zone 6: Electricity consumption benchmarks by household size



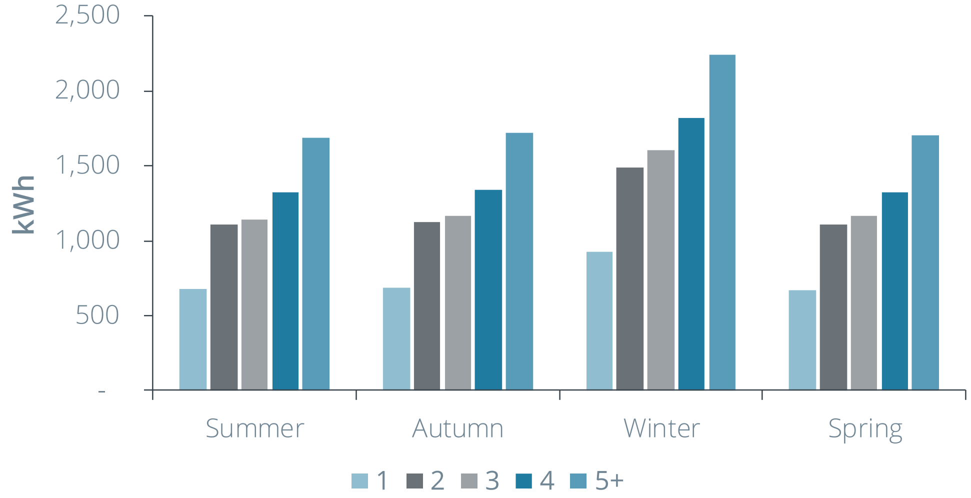

*Source: Frontier Economics*

**Figure 12**: SA Climate Zone 6: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

**Figure 13**: VIC Climate Zone 6: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

Overall, electricity consumption in Climate Zone 6 is highest in winter. Consumption in winter is approximately 30% higher than in summer, autumn and spring which have fairly similar average consumption. We found that Climate Zone 6 has the lowest average consumption in summer, autumn and spring, and the lowest aggregate electricity consumption overall.

Consumption in New South Wales was considerably higher than in Victoria and South Australia, by approximately 25% on average. The difference is typically more pronounced in summer and least pronounced in winter.

There is generally steady increase in electricity consumption from smaller to larger households.

A depiction of average seasonal consumption by household size and state in Climate Zone 6, including the electricity consumption benchmarks, is presented in **Figure 28** in Appendix E.

### 4.2.6 Climate Zone 7

The sample includes 780 households in Climate Zone 7[11], spread across four states and territories. There are 342 households in Tasmania, which is entirely within Climate Zone 7, 203 in the ACT which is also entirely in climate 7 and a further 167 and 68 respondents in the alpine regions of Victoria and New South Wales respectively.

Households in New South Wales and the ACT were pooled, but separate benchmarks were estimated for Tasmania and Victoria. The 2, 3, and 4 person households in Victoria were pooled in all seasons. The 4 and 5+ person households in New South Wales and the ACT were pooled in winter. Further information on the benchmark model for Climate Zone 7 is set out in Appendix B.

The electricity consumption benchmarks for Climate Zone 7 are presented in **Table 18**, **Figure 14**, **Figure 15**, **Figure 16**, and **Figure 17**.

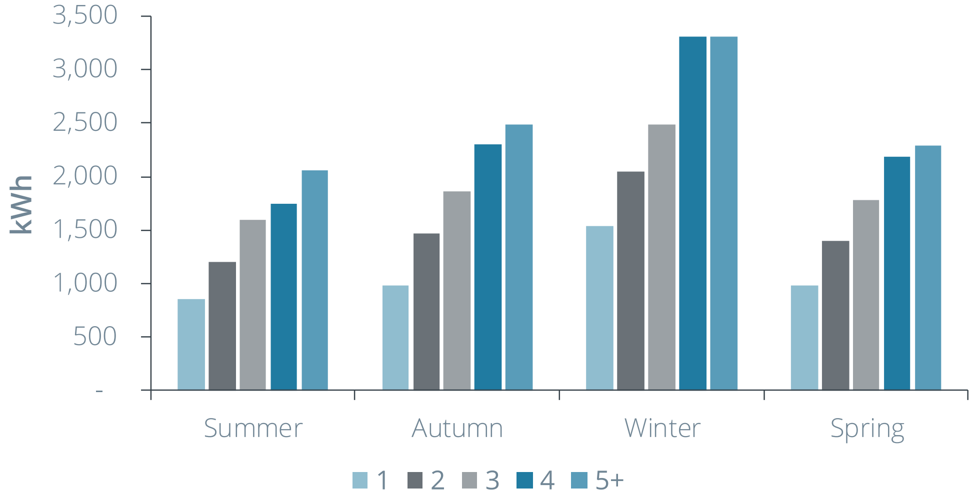
[11] The Climate Zone 7 benchmarks apply to households in Climate Zones 7 and 8.

**Table 18:** Climate Zone 7: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| ACT | 1 | 850 | 987 | 1,543 | 980 |
| ACT | 2 | 1,200 | 1,468 | 2,042 | 1,397 |
| ACT | 3 | 1,598 | 1,859 | 2,485 | 1,780 |
| ACT | 4 | 1,745 | 2,303 | 3,313 | 2,181 |
| ACT | 5+ | 2,058 | 2,492 | 3,313 | 2,287 |
| NSW | 1 | 887 | 1,067 | 1,715 | 1,050 |
| NSW | 2 | 1,237 | 1,549 | 2,215 | 1,466 |
| NSW | 3 | 1,635 | 1,940 | 2,658 | 1,850 |
| NSW | 4 | 1,782 | 2,384 | 3,486 | 2,251 |
| NSW | 5+ | 2,094 | 2,572 | 3,486 | 2,357 |
| TAS | 1 | 983 | 1,394 | 2,182 | 1,444 |
| TAS | 2 | 1,581 | 2,109 | 2,950 | 2,144 |
| TAS | 3 | 1,623 | 2,192 | 3,286 | 2,374 |
| TAS | 4 | 1,946 | 2,571 | 3,642 | 2,661 |
| TAS | 5+ | 2,178 | 2,719 | 3,706 | 2,952 |
| VIC | 1 | 739 | 718 | 1,166 | 720 |
| VIC | 2 | 1,263 | 1,280 | 1,753 | 1,278 |
| VIC | 3 | 1,263 | 1,280 | 1,753 | 1,278 |
| VIC | 4 | 1,263 | 1,280 | 1,753 | 1,278 |
| VIC | 5+ | 1,918 | 2,023 | 2,947 | 2,128 |

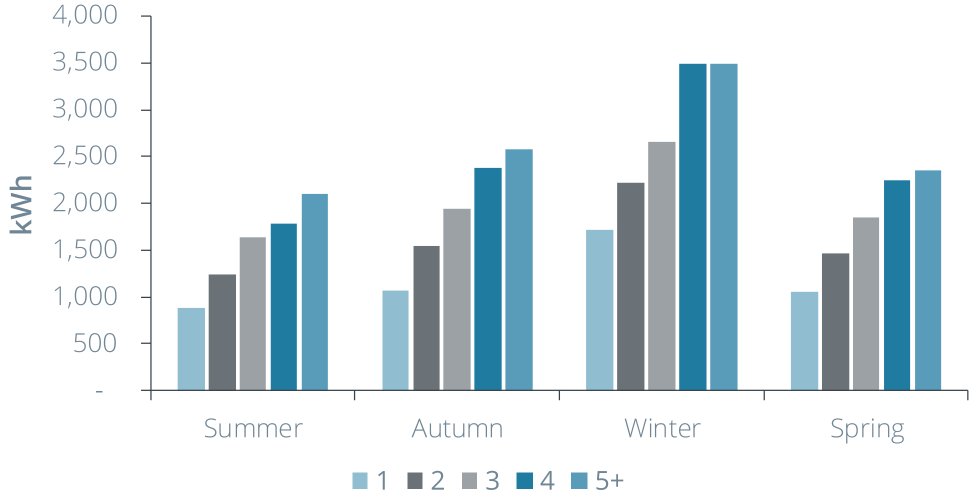
*Source: Frontier Economics*

**Figure 14**: ACT Climate Zone 7: Electricity consumption benchmarks by household size



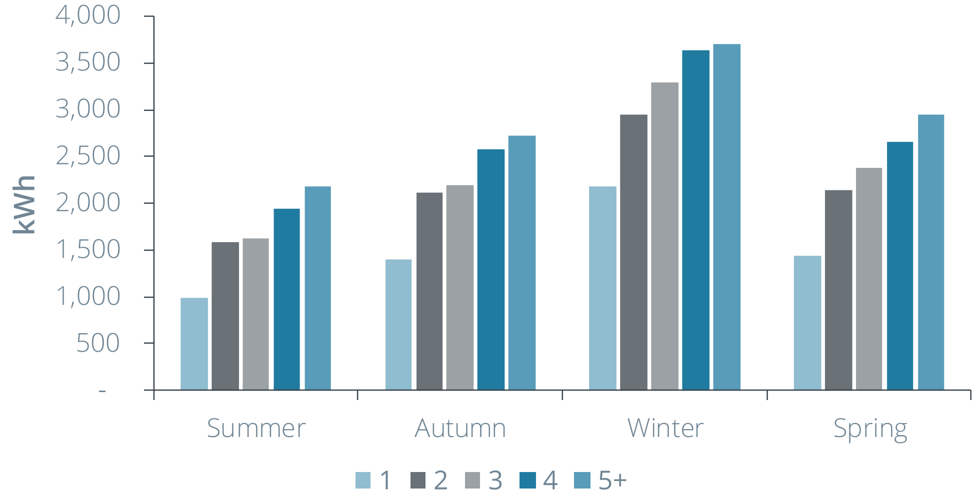

*Source: Frontier Economics*

**Figure 15**: NSW Climate Zone 7: Electricity consumption benchmarks by household size



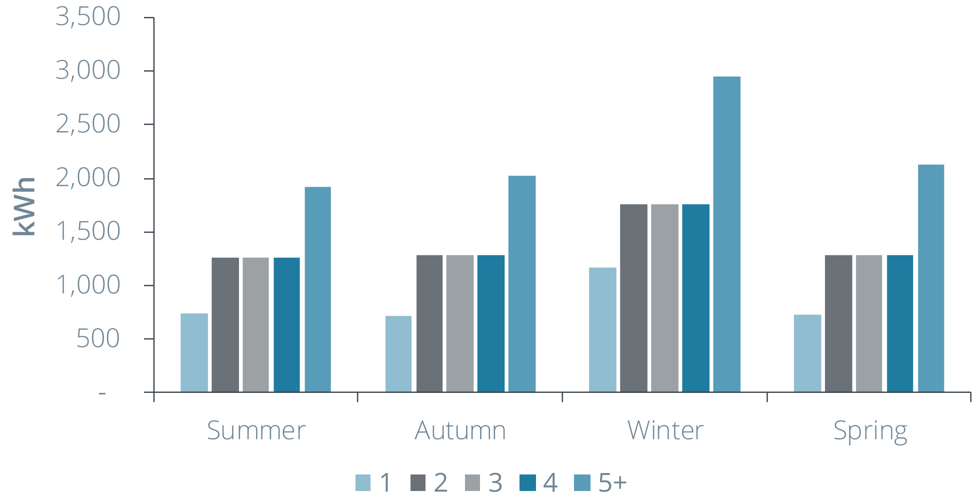

*Source: Frontier Economics*

**Figure 16**: TAS Climate Zone 7: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

**Figure 17**: VIC Climate Zone 7: Electricity consumption benchmarks by household size




*Source: Frontier Economics*

Overall, electricity consumption in Climate Zone 7 is the highest on average across all climate zones. It is a cold climate zone, and electricity consumption is the highest in winter and lowest in summer. It is the only climate zone where average consumption is the lowest in summer. It is also the most seasonal, with winter making up the largest proportion of annual consumption of any season across the climate zones.

Electricity consumption in Climate Zone 7 is highest in Tasmania. It is about 25% higher on average than consumption in ACT and NSW for the corresponding household size, with the largest difference in spring and the smallest in summer.

In Victoria, electricity consumption is lower than the other areas of Climate Zone 7. Again, the difference is the least pronounced during summer.

A depiction of average seasonal consumption by household size and state in Climate Zone 7, including the electricity consumption benchmarks, is presented in **Figure 29** in Appendix E.

### 4.2.7 South Australian benchmarks

As outlined in Section 4.1.3, the South Australian consumption benchmarks were estimated as a population weighted average of the consumption benchmarks for South Australia in the underlying climate zones. These benchmarks, for Climate Zones 4, 5, and 6 are set out in **Table 15**, **Table 16**, and **Table 17**.

This section summarises the values for the South Australian localised zones.

**Adelaide and environs**

The Adelaide and environs localised zone is made up of households in Climate Zones 5 and 6 as follows:

- Climate Zone 5: 92%
- Climate Zone 6: 8%.

The Adelaide and environs benchmarks are therefore calculated as a weighted average of the Climate Zones 5 and 6 electricity consumption benchmarks using the population weights and are set out in **Table 19** below.

**Table 19:** Adelaide and environs: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 687 | 704 | 894 | 651 |
| SA | 2 | 1,225 | 1,188 | 1,526 | 1,107 |
| SA | 3 | 1,460 | 1,442 | 1,846 | 1,354 |
| SA | 4 | 1,740 | 1,652 | 2,090 | 1,552 |
| SA | 5+ | 2,080 | 2,019 | 2,688 | 1,932 |

*Source: Frontier Economics*

**Mount Lofty Ranges**

The Mount Lofty Ranges localised zone is made up of households in Climate Zones 5 and 6 as follows:

- Climate Zone 5: 4%
- Climate Zone 6: 96%.

The Mount Lofty Ranges benchmarks are therefore calculated as a weighted average of the Climate Zones 5 and 6 electricity consumption benchmarks using the population weights and are set out in **Table 20** below.

**Table 20:** Mount Lofty Ranges: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 674 | 729 | 1,028 | 706 |
| SA | 2 | 1,116 | 1,172 | 1,597 | 1,149 |
| SA | 3 | 1,157 | 1,222 | 1,720 | 1,211 |
| SA | 4 | 1,342 | 1,397 | 1,936 | 1,372 |
| SA | 5+ | 1,703 | 1,776 | 2,368 | 1,752 |

*Source: Frontier Economics*

### Central North

The Central North localised zone is made up of households in Climate Zones 4, 5 and 6 as follows:

- Climate Zone 4: 45%
- Climate Zone 5: 52%
- Climate Zone 6: 3%.

The Central North benchmarks are therefore calculated as a weighted average of the Climate Zones 4, 5 and 6 electricity consumption benchmarks using the population weights and are set out in **Table 21** below.

**Table 21:** Central North: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 800 | 773 | 992 | 713 |
| SA | 2 | 1,337 | 1,257 | 1,663 | 1,205 |
| SA | 3 | 1,878 | 1,764 | 2,196 | 1,625 |
| SA | 4 | 2,033 | 1,880 | 2,330 | 1,735 |
| SA | 5+ | 2,220 | 2,081 | 2,662 | 1,944 |

*Source: Frontier Economics*

### Mid North

The Mid North localised zone is made up of households in Climate Zones 4, 5 and 6 as follows:

- Climate Zone 4: 1%

- Climate Zone 5: 32%
- Climate Zone 6: 67%.

The Mid North benchmarks are therefore calculated as a weighted average of the Climate Zones 4, 5, and 6 electricity consumption benchmarks using the population weights and are set out in **Table 22** below.

**Table 22:** Mid North: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 680 | 722 | 986 | 689 |
| SA | 2 | 1,153 | 1,179 | 1,576 | 1,137 |
| SA | 3 | 1,264 | 1,300 | 1,767 | 1,263 |
| SA | 4 | 1,478 | 1,484 | 1,991 | 1,434 |
| SA | 5+ | 1,830 | 1,857 | 2,473 | 1,811 |

*Source: Frontier Economics*

### Murraylands and Riverlands

The Murraylands and Riverlands localised zone is made up of households in Climate Zones 5 and 6 as follows:

- Climate Zone 5: 85%
- Climate Zone 6: 15%.

The Murraylands and Riverlands benchmarks are therefore calculated as a weighted average of the climate zones 5 and 6 electricity consumption benchmarks using the population weights and are set out in **Table 23** below.

**Table 23:** Murraylands and Riverlands: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 686 | 706 | 905 | 655 |
| SA | 2 | 1,216 | 1,187 | 1,532 | 1,110 |
| SA | 3 | 1,436 | 1,424 | 1,836 | 1,342 |
| SA | 4 | 1,709 | 1,631 | 2,077 | 1,537 |
| SA | 5+ | 2,051 | 1,999 | 2,662 | 1,917 |

*Source: Frontier Economics*

### Yorke Peninsula and Kangaroo Island

The Yorke Peninsula and Kangaroo Island localised zone is made up of households in Climate Zones 5 and 6 as follows:

- Climate Zone 5: 85%
- Climate Zone 6: 15%.

The Yorke Peninsula and Kangaroo Island benchmarks are therefore calculated as a weighted average of the Climate Zones 5 and 6 electricity consumption benchmarks using the population weights and are set out in **Table 24** below.

**Table 24:** Yorke Peninsula and Kangaroo Island: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 686 | 706 | 905 | 655 |
| SA | 2 | 1,216 | 1,187 | 1,532 | 1,110 |
| SA | 3 | 1,435 | 1,424 | 1,836 | 1,342 |
| SA | 4 | 1,708 | 1,631 | 2,077 | 1,537 |
| SA | 5+ | 2,050 | 1,999 | 2,662 | 1,917 |

*Source: Frontier Economics*

### Port Augusta and Pastoral

The Port Augusta and Pastoral localised zone is made up of households in Climate Zones 4, 5 and 6 as follows:

- Climate Zone 4: 76%
- Climate Zone 5: 16%
- Climate Zone 6: 8%.

The Port Augusta and Pastoral benchmarks are therefore calculated as a weighted average of the Climate Zones 4, 5 and 6 electricity consumption benchmarks using the population weights and are set out in **Table 25** below.

**Table 25:** Port Augusta and Pastoral: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 877 | 823 | 1,073 | 761 |
| SA | 2 | 1,406 | 1,304 | 1,766 | 1,277 |
| SA | 3 | 2,143 | 1,969 | 2,430 | 1,802 |
| SA | 4 | 2,202 | 2,016 | 2,485 | 1,846 |
| SA | 5+ | 2,283 | 2,103 | 2,614 | 1,936 |

*Source: Frontier Economics*

### West Coast

The West Coast localised zone is made up of households in Climate Zones 4 and 5 as follows:

- Climate Zone 4: 8%
- Climate Zone 5: 92%.

The West Coast benchmarks are therefore calculated as a weighted average of the Climate Zones 4 and 5 electricity consumption benchmarks using the population weights and are set out in **Table 26** below.

**Table 26:** West Coast: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 709 | 715 | 901 | 658 |
| SA | 2 | 1,254 | 1,202 | 1,545 | 1,121 |
| SA | 3 | 1,558 | 1,517 | 1,919 | 1,413 |
| SA | 4 | 1,824 | 1,713 | 2,145 | 1,599 |
| SA | 5+ | 2,135 | 2,049 | 2,709 | 1,948 |

*Source: Frontier Economics*

### Eastern Eyre

The Eastern Eyre localised zone is made up of households in Climate Zones 4 and 5 as follows:

- Climate Zone 4: 48%
- Climate Zone 5: 52%.

The Eastern Eyre benchmarks are therefore calculated as a weighted average of the Climate Zones 4 and 5 electricity consumption benchmarks using the population weights and are set out in **Table 27** below.

**Table 27:** Eastern Eyre: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 809 | 777 | 995 | 716 |
| SA | 2 | 1,349 | 1,263 | 1,671 | 1,211 |
| SA | 3 | 1,918 | 1,794 | 2,226 | 1,650 |
| SA | 4 | 2,068 | 1,905 | 2,353 | 1,754 |
| SA | 5+ | 2,243 | 2,094 | 2,670 | 1,950 |

*Source: Frontier Economics*

**South East**

The South East localised zone is made up entirely of households in Climate Zone 6. The South East benchmarks are therefore the same as the Climate Zone 6 benchmarks and are set out in **Table 28** below.

**Table 28:** South East: Electricity consumption benchmarks (kWh)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 673 | 730 | 1,035 | 709 |
| SA | 2 | 1,110 | 1,171 | 1,600 | 1,151 |
| SA | 3 | 1,142 | 1,211 | 1,713 | 1,204 |
| SA | 4 | 1,322 | 1,384 | 1,929 | 1,363 |
| SA | 5+ | 1,685 | 1,764 | 2,352 | 1,743 |

*Source: Frontier Economics*

# 5 Gas consumption benchmarks

## 5.1 Summary of approach

### 5.1.1 Purpose and structure of consumption benchmarks

The purpose of the gas consumption benchmarks is similar to the electricity consumption benchmarks – that is to allow residents to compare their usage to similar households in their area. However, unlike the electricity consumption benchmarks there is no obligation on retailers to display the gas benchmarks on customer bills. Retailers that wish to provide this additional information to their customers are able to do so at their discretion.

The simple benchmarks calculated do not explain all of the drivers of gas consumption in the household, and households may have gas consumption considerably higher or lower than the benchmarks for a range of reasons.

Consistent with the 2017 benchmarks, we developed the gas consumption benchmarks at the state and territory jurisdictional level.

Residential gas consumption is generally for three broad purposes:

- Space heating
- Water heating
- Cooking.

In the 2017 benchmarks, these end-use categories were considered as potential 'benchmark' factors. In some regions the gas benchmarks were presented with a single factor selected from the above set of end uses (with a higher value for households 'with' the factor and a lower value for households 'without'). In other regions the benchmarks were presented as an overall average with no benchmark factors. Where a single benchmark factor was used, it was the space heating factor.

The 2017 benchmark report found that water heating and cooking did not tend to be useful factors in a model that included household size variables. The most likely explanation was that energy consumption for these categories scaled neatly with household sizes, so that most of the variance due to hot water and cooking would be caught by the household size variables. However, the gas consumption from space heating was less dependent on household size.

For example, gas consumption for water heating may incrementally increase with each additional member of the household, since each household member results in additional hot showers. However, gas consumption for a space heater would likely be less correlated with household size since gas heating would be similar regardless of whether 2 or 4 people were sitting in the room.

As outlined in Section 3 the gas sample size in Tasmania is only 18 households, which is too small to independently estimate benchmarks. We considered that the most appropriate treatment was to pool Tasmania and the ACT to develop shared gas benchmarks. Gas consumption in the ACT was most similar to Tasmania, and they share the most similarity in climate zones at the jurisdiction level. We also considered pooling Tasmania with Victorian, however the ACT was a closer fit. This ensured a minimum sample size of at least 15 for each household size.

As in the electricity benchmarks, sometimes there are 'backwards steps' in gas consumption, where the average gas consumption for a larger household is less than for a smaller household. Showing backward steps on a gas bill would be confusing for a retail customer. We managed backwards steps and pooling in the same manner as for the electricity consumption benchmarks. We tested whether it would be reasonable to pool household sizes to avoid backwards steps.

Within each jurisdiction, we estimated a number of different models to select a preferred model. This necessarily involved professional judgement; however, we were guided by a number of criteria, such as:

- Maximising the explanatory power of the model according to a number of statistical criteria
- Reducing the number of backwards steps by pooling across household sizes where possible.

Further information on the model selection process for the gas benchmarks is set out in Appendix C.

## 5.2 Summary of results

### 5.2.1 ACT and Tasmania

As noted above, the Tasmania and ACT samples are pooled in the same model estimating a single set of combined benchmarks for the two jurisdictions. This pooling was supported by statistical tests. To avoid backward steps, we also pooled 2 and 3 person households in autumn, winter and spring, and 4 and 5+ person households in summer and autumn. Further information on the gas benchmark model for the ACT and Tasmania is set out in Appendix C.

The model was estimated using a sample of 180 households, consisting of 162 households in the ACT and 18 households in Tasmania.

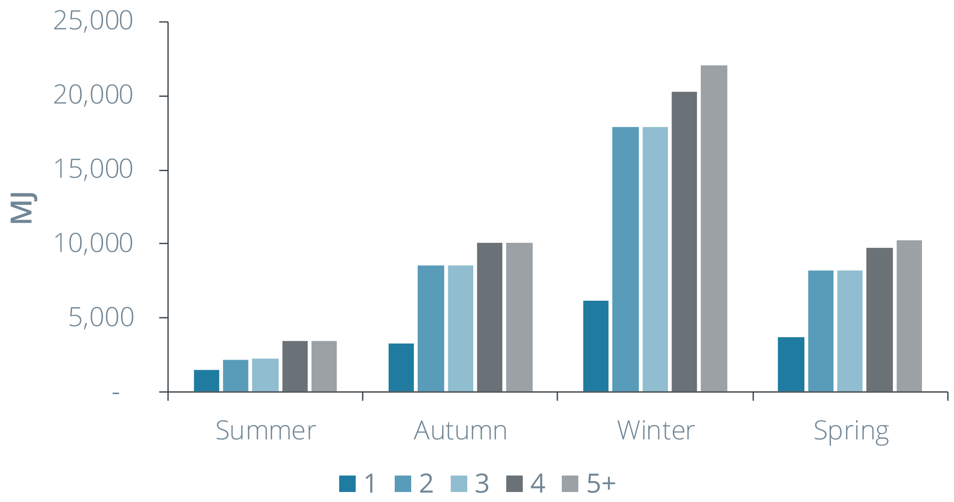
The ACT and Tasmanian gas consumption benchmarks are presented in **Table 29** and **Figure 18** below.

**Table 29:** ACT and Tasmania: Gas consumption benchmarks (MJ)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| ACT/TAS | 1 | 1,498 | 3,276 | 6,188 | 3,725 |
| ACT/TAS | 2 | 2,189 | 8,542 | 17,918 | 8,221 |
| ACT/TAS | 3 | 2,254 | 8,542 | 17,918 | 8,221 |
| ACT/TAS | 4 | 3,442 | 10,100 | 20,305 | 9,711 |
| ACT/TAS | 5+ | 3,442 | 10,100 | 22,060 | 10,206 |

*Source: Frontier Economics*

**Figure 18**: ACT and Tasmania: Gas consumption benchmarks by household size




*Source: Frontier Economics*

Gas consumption in the ACT and Tasmania is quite high, following Victoria as the regions with the highest average gas consumption. This reflects the cool climate, and high energy requirements for heating spaces and water, particularly in cooler parts of the year.

There is a strong seasonal component to average gas consumption, with consumption much higher in winter. Average household consumption in winter is approximately twice average consumption in autumn and spring, and over six times as high as average consumption in summer.

A depiction of average gas seasonal consumption by household size and state in the ACT and Tasmania, including the gas consumption benchmarks, is presented in **Figure 30** in Appendix F.

### 5.2.2 New South Wales

The gas sample includes 1,062 households in New South Wales.

There was no pooling across households in any of the seasons. Further information on the gas benchmark model for New South Wales is set out in Appendix C.

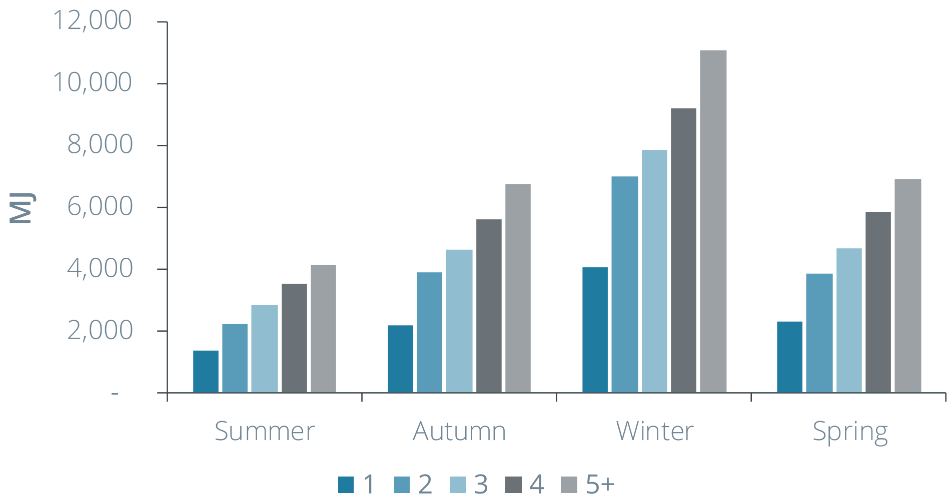
The New South Wales gas consumption benchmarks are presented in **Table 30** and **Figure 19** below.

**Table 30:** New South Wales: Gas consumption benchmarks (MJ)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| NSW | 1 | 1,340 | 2,168 | 4,033 | 2,294 |
| NSW | 2 | 2,219 | 3,901 | 6,990 | 3,835 |
| NSW | 3 | 2,841 | 4,636 | 7,858 | 4,643 |
| NSW | 4 | 3,538 | 5,593 | 9,172 | 5,857 |
| NSW | 5+ | 4,117 | 6,727 | 11,055 | 6,900 |

*Source: Frontier Economics*

**Figure 19**: New South Wales: Gas consumption benchmarks by household size




*Source: Frontier Economics*

Average gas consumption in New South Wales tends to increase steadily by household size. The average consumption is highest in winter, similar in autumn and spring, and considerably lower than summer. However, the seasonality is not as strong as some of the other regions. Winter consumption is a little less than three times as high as summer consumption.

Average consumption overall is significantly higher than Queensland, but lower than ACT and Victoria. It is similar in magnitude to South Australia.

A depiction of average gas seasonal consumption by household size in New South Wales, including the gas consumption benchmarks, is presented in **Figure 31** in Appendix F.

### 5.2.3 Queensland

The gas sample includes 153 households in Queensland.

There was no pooling across households in any of the seasons. Further information on the gas benchmark model for Queensland is set out in Appendix C.

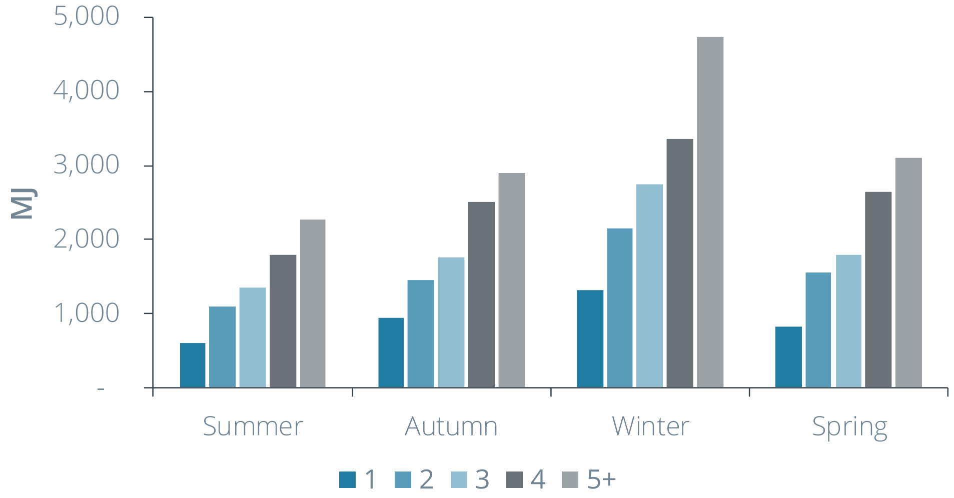
The Queensland gas consumption benchmarks are presented in **Table 31** and **Figure 20** below.

**Table 31:** Queensland: Gas consumption benchmarks (MJ)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| QLD | 1 | 599 | 939 | 1,314 | 826 |
| QLD | 2 | 1,099 | 1,450 | 2,158 | 1,554 |
| QLD | 3 | 1,355 | 1,757 | 2,745 | 1,792 |
| QLD | 4 | 1,793 | 2,505 | 3,360 | 2,637 |
| QLD | 5+ | 2,274 | 2,894 | 4,736 | 3,110 |

*Source: Frontier Economics*

**Figure 20**: Queensland: Gas consumption benchmarks by household size




*Source: Frontier Economics*

Average gas consumption is materially lower in Queensland than other regions. This is broadly in line with expectations given the warmer climate of Queensland and reduced heating load in general. The proportions of households which use gas for heating water and space heating are lower in Queensland than the other regions of Australia.

Like several other regions, consumption is the highest in winter, lowest in summer and quite similar across autumn and spring. However, the seasonality of consumption is much less than the cooler regions. Winter consumption is approximately twice as high as average summer consumption, and 50% higher than average autumn and spring consumption.

A depiction of average gas seasonal consumption by household size in Queensland, including the gas consumption benchmarks, is presented in **Figure 32** in Appendix F.

### 5.2.4 South Australia

The gas sample includes 373 households in South Australia.

We pooled 3, 4 and 5+ person households in winter and spring, and 3 and 4 person households in autumn. Further information on the gas benchmark model for South Australia is set out in Appendix C.

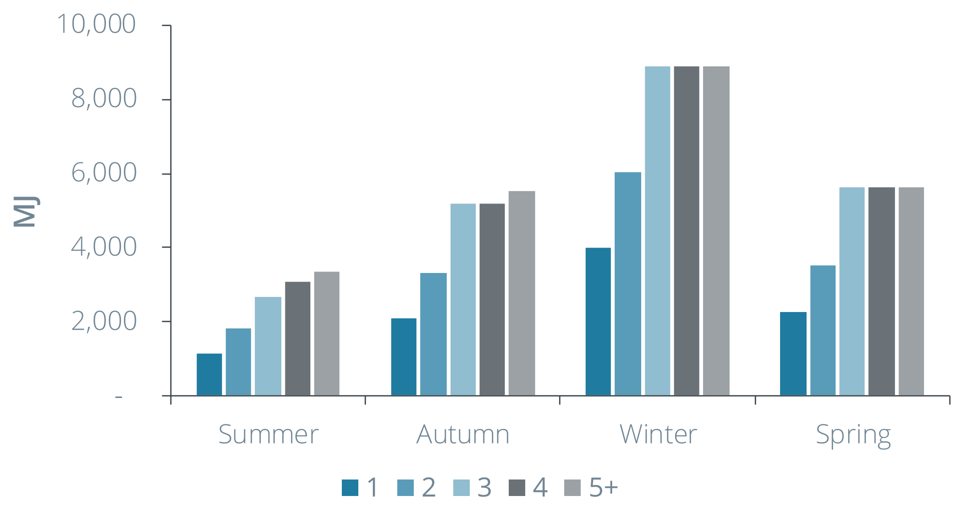
The South Australia gas consumption benchmarks are presented in **Table 32** and **Figure 21** below.

**Table 32:** South Australia: Gas consumption benchmarks (MJ)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| SA | 1 | 1,124 | 2,085 | 3,979 | 2,257 |
| SA | 2 | 1,807 | 3,313 | 6,023 | 3,528 |
| SA | 3 | 2,655 | 5,173 | 8,874 | 5,619 |
| SA | 4 | 3,084 | 5,173 | 8,874 | 5,619 |
| SA | 5+ | 3,349 | 5,537 | 8,874 | 5,619 |

*Source: Frontier Economics*

**Figure 21**: South Australia: Gas consumption benchmarks by household size




*Source: Frontier Economics*

Overall, gas consumption in South Australia tended to be similar to New South Wales in magnitude and seasonality. Consumption is the highest in winter, similar in autumn and spring, and lower in summer.

A depiction of average gas seasonal consumption by household size in South Australia, including the gas consumption benchmarks, is presented in **Figure 33** in Appendix F.

### 5.2.5 Victoria

The gas sample includes 1,380 households in Victoria.

We pooled 2 and 3 person households in autumn, winter and spring. Further information on the gas benchmark model for Victoria is set out in Appendix C.

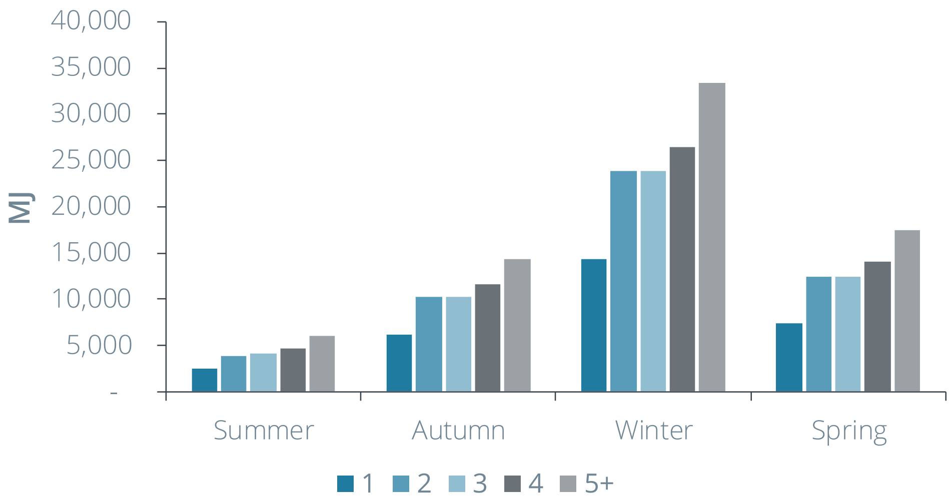
The Victorian gas consumption benchmarks are presented in **Table 33** and **Figure 22** below.

**Table 33:** Victoria: Gas consumption benchmarks (MJ)

| State / Territory | Household size | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| VIC | 1 | 2,484 | 6,178 | 14,375 | 7,377 |
| VIC | 2 | 3,911 | 10,230 | 23,855 | 12,466 |
| VIC | 3 | 4,192 | 10,230 | 23,855 | 12,466 |
| VIC | 4 | 4,694 | 11,567 | 26,426 | 14,111 |
| VIC | 5+ | 6,028 | 14,339 | 33,375 | 17,444 |

*Source: Frontier Economics*

**Figure 22**: Victoria: Gas consumption benchmarks by household size




*Source: Frontier Economics*

Average seasonal gas consumption in Victoria is the highest across all of the jurisdictions. On average, the benchmarks are over 50% higher than corresponding benchmarks in the ACT and Tasmania, the second highest regions. The proportional difference is highest over summer.

Consumption is the highest in winter, followed by spring, autumn and summer. The seasonality is significant, and a similar magnitude to the seasonality of consumption in the ACT. Winter consumption is approximately double spring, and almost six times as high as summer consumption. This reflects the cool climate, and high penetration of gas for space heating in Victoria relative to the other jurisdictions.

A depiction of average gas seasonal consumption by household size in Victoria, including the gas consumption benchmarks, is presented in **Figure 34** in Appendix F.

# 6 Potential improvements to benchmarking methodology

This section sets out improvements that could be made to the methodology in future iterations of the benchmarking exercise.

## 6.1 Sampling methodology

A major challenge in developing the benchmarks is constructing a sufficiently large sample to robustly and accurately develop consumption benchmarks for all types of households. The Australian population is not evenly distributed among climate zones. As set out in Section 3.3.1, certain combinations of climate zone, state, and household size have low populations, and hence small sample sizes. Others have high populations and large sample sizes. In particular:

- Climate zones which include major urban centres (such as Climate Zones 2, 5, and 6 which include Sydney, Brisbane and Melbourne respectively) generally have high numbers of respondents. Climate zones that cover more remote areas (like Climate Zones 1, 3, and 4) generally have low numbers of respondents. This largely reflects the difference in population between those regions.
- Household sizes which are more common (such as 2 person households) have higher numbers of respondents than household sizes which are less common (such as households with 5 or more people).

Larger samples produce more robust estimates of consumption. When the sample sizes are small, the estimates are susceptible to influence from the characteristics of a few particular households in the estimation sample. One response to this is to try to survey more households, and boost overall sample sizes. However, the issue isn't the overall sample size – it is sample size in the smallest sample group. Increasing the overall sample size may increase the smallest sample group, but not in a very efficient way.

In an ideal sample design, there would be a similar number of respondents in each sample group. As an example, the number of 2 person households in QLD Climate Zone 2 (including Brisbane) would ideally be close to the number of 4 person households in QLD Climate Zone 3. In practice, achieving this would involve substantially oversampling in the least populated groups, and under-sampling in the most populated groups.

However, most survey panels are not designed in that way. It is more common that panels are designed to be representative of the Australian population overall, or Australian consumers of a particular set of products. It is not common for panel groups to have national samples deliberately skewed to such a degree to remote parts of the country.

It would be possible to build a sample that is weighted towards less populated regions. The weighting could be designed purposefully for energy consumption benchmarks. This would likely involve more targeted, offline recruitment in certain areas to complement existing panels. This approach would be more time consuming, costly, and complex than using existing panels. Therefore to manage these factors it would be appropriate to reduce recruitment from high population areas as well as increasing recruitment from low population areas. We recommend that the AER give consideration to expanding its recruitment approach

This type of approach would take considerably more resources, and require a greater degree of planning before the benchmarking exercise. However, it could greatly enhance the robustness of the consumption benchmarks for customers located outside major population centres. It is important for the AER to consider the cost of adopting this approach, and whether it would continue to be efficient and proportional.

## 6.2 Guiding electricity retailers to use information available

As discussed in Section 4.1, we developed electricity consumption benchmarks based on average electricity consumption within a climate zone for inclusion on customer bills. These do not include any 'benchmark factors' to differentiate different types of households. This was a departure from the approach used in previous benchmarking exercises, where the benchmarks in most climate zones were differentiated by some factor (for example, depending on the climate zone, whether households had a swimming pool, mains gas, or underfloor heating).

Previously, electricity retailers were provided both sets of benchmarks (i.e. with and without the factor). However, in most cases the retailer would not be able to differentiate their customers according to the benchmark factor and would therefore provide all households in the region the same benchmark. This was typically the benchmark which applied to a higher proportion of households.

Electricity retailers typically have limited information on their customers. They cannot observe many of the household characteristics that are relevant to average energy consumption, such as the appliances used in the house. However, there are a small number of characteristics that retailers can observe. These characteristics could potentially be used to allow more targeted benchmarks to be applied to certain households. They include the following:

- Whether the household has controlled load connection, which would be reflected in the electricity plan and billing structure
- Whether the household has solar PV, which would be reflected in the electricity plan and billing structure
- In some instances, an electricity retailer may know whether a customer has a mains gas connection because they are also their gas retailer. However, this doesn't always apply as some households have different retailers for electricity and gas.

In most climate zones, and most seasons, one or more of these observable characteristics are useful explanatory factors for electricity consumption.

We recommend that the AER consider developing consumption benchmarks that account for factors which are observable by retailers.

This would increase the regulatory burden on retailers and the AER. However, it would improve the relevance of benchmarking information available to customers through their bills. It would likely require consultation with retailers and consumers to assess whether the benefit to consumers is likely to exceed additional costs. We recommend that the AER give consideration to this option for future iterations of the consumption benchmarks.

## 6.3 Use of weather / climate data

Under the NERR, the minister responsible for energy in each jurisdiction is able to select the geographic regions for which the consumption benchmarks are estimated. The ABCB climate zones, which currently form the basis for the benchmarks, are broadly suitable. They consider a range of climatic factors which are relevant to energy consumption. However, separating the benchmarks by discrete regions does have some issues.

Firstly, some of the climate zones have fewer people than others, as discussed above in Section 6.1. This means that the precision of the estimated benchmarks varies between climate zones. Secondly, there are boundary effects at the edge of climate zones. One household may receive one set of benchmarks on their bills, while their neighbour across the road (who is in a different climate zone) receives another set.

As an alternative to the climate zones, it would be possible to estimate benchmarks using a more continuous measurement of climatic variables. The Bureau of Meteorology manages a large number of weather stations across the country. The data available at weather stations typically includes time series on temperature, humidity, rainfall and other factors relevant to household energy consumption. Using the postcode provided in the survey it would be possible to match households with their nearest weather station or stations.

Using the local weather data for each observation, it would be possible to build a model that estimates benchmark energy consumption by directly using climate data such as average temperatures, maximum and minimum temperatures, heating and cooling degree days, humidity and rainfall. Bespoke benchmarks for different regions could be developed based on the climatic conditions in that region.

Again, this would likely be a more complex benchmarking exercise compared to the current approach of developing benchmarks by climate zone. An additional challenge is that the decision is not entirely within the AER's control. It would require the ministers responsible for energy to agree to developing energy consumption benchmarks on that basis. However, we recommend that this approach be considered in further detail.

# A Collecting and cleaning energy consumption data

This technical appendix sets out our approach to collecting energy consumption data from AEMO, electricity networks, and gas networks. It also describes the data cleaning and processing we did to develop seasonal electricity and gas consumption estimates for each respondent.

## Collecting electricity consumption data

As described in Section 2.1, survey respondents were asked to provide their NMI, which they were directed to find on their electricity bills. We used the NMI to match survey responses with metered electricity consumption data.

In previous benchmarking studies, the electricity consumption data for the respondents was provided by electricity distribution networks (DNSPs).

For this benchmarking study, electricity consumption data was collected from AEMO in the first instance, in order to:

- Streamline the data collection process, by collecting data from a single source – rather than 13 DNSPs.
- Mitigate the regulatory burden on DNSPs given the impact of COVID-19 restrictions on operations occurring at the time.

The AER submitted a data request to AEMO for the 6,970 NMIs in the survey dataset. The data request was for:

- **Electricity consumption data for CY2019**. At the most granular level available for the NMI. This was either interval meter data, accumulation meter data, [12] or both, depending on the metering configuration for the particular NMI over the study period.
- **Solar PV installation data**. Information available on the date and size of any solar PV installation associated with the NMI known to AEMO
- **Register data**. Other data on the NMI, including whether it has a controlled load connection.

However, AEMO only holds consumption data for a subset of NMIs in the National Electricity market (NEM), which it receives from the Metering Data Providers (MDPs) which provide data separately to DNSPs. The proportion of NMIs for which AEMO has data differs by region but is highest in Victoria and lowest in Tasmania and the ACT.

AEMO provided electricity consumption data for 5,919 NMIs to the AER. For an additional 731 NMIs, it provided register data, but could not provide consumption data. A summary of the consumption data provided by AEMO to the AER is presented in **Table 34** below.

[12] Interval meters record electricity consumption for every 30-minute interval. Accumulation meters only record the total consumption between meter reads, which is typically about 90 days but can vary for a range of reasons.

**Table 34:** AEMO data request

| Data request component | Count |
|---|---|
| NMIs in data request | 6,970 |
| AEMO provided register data | 6,650 |
| AEMO provided electricity consumption data: Interval | 3,215 |
| AEMO provided electricity consumption data: Accumulation | 2,977 |
| **AEMO provide electricity consumption data: Total** | **5,919** |

*Source: Frontier Economics. Note that the total number of NMIs with electricity consumption data is lower than the sum of interval and accumulation counts, as some NMIs are included in both categories (for example if an accumulation meter was switched to a smart meter partway through the study period).*

The AEMO consumption data was provided in Meter Data Management Format (MDM Format). This format is described in detail in AEMO's MDM File Format and Load Process documentation.[13] In the MDM format, there are separate specifications for interval data and accumulation data. There are some particular characteristics of the formats which are important to note for the purpose of this study.

- **Interval data**. In the MDM format, interval data is presented as the 'Net' of 'Import' and 'Export' channels for each thirty-minute interval.[14] The direction of flow during the interval is indicated by the sign of the reading. For example, a value of 3 would indicate 3kWh of net 'Import' (from the grid to the consumer). A value of -2 would indicate 2kWh of net 'Export' (from the consumer to the grid – for example from solar PV panels generating more than consumption).

  With this format, there is a small lack of precision in instances where the household both imports and exports during the same interval. This could occur for a range of reasons. An example would be if solar PV generation is closely matched by the customer's own consumption - but the balance between the two is thrown out by a change in cloud cover or shift in load (turning a kettle or heater on/off) partway through the interval.

  With this format it is also not possible to identify and differentiate controlled load consumption from general consumption, even if it is known that a household has a controlled load connection.

[13] AEMO, 2020, *MDM File Format and Load Process 5.14 Final*. Online at https://aemo.com.au/-/media/files/electricity/nem/5ms/systems-workstream/2020/mdm-file-format-and-load-process.pdf?la=en&hash=27FA623BB0606D5F77219E8FCF824998

[14] 'Import' or 'Export' may have different interpretations depending on the perspective taken. The same energy flow from a rooftop PV system may be seen as an 'Export' to the grid by the household, and an 'Import' into the grid by AEMO. For the remainder of this paper, unless otherwise noted, we use 'Import' to mean energy flows in the direction from the grid to the household, and 'Export' to mean energy flows from the household to the grid.

- Accumulation data. In the MDM format, accumulation meter data is presented separately for each datastream. The direction of flow during the meter read period is indicated by the sign of the reading. Solar PV channels (or 'Export') are presented separately in almost all instances but are not labelled as such. It is generally possible to infer that a channel is solar PV based on the sign (positive or negative) of the reading.

  The datastreams are labelled with a suffix, defined by the DNSP (for example indicating controlled load, solar PV, general consumption). It is necessary to combine the data with datastream suffix mappings for each DNSP to interpret and identify controlled load (and solar PV export – although the sign of the reading can typically be used for this).

The remaining electricity consumption data required to produce the benchmarks was collected from the DNSPs.[15] We submitted a data request to DNSPs which included NMIs in three categories:

1. NMIs for which AEMO was not able to provide data
2. NMIs with an interval meter and solar PV to understand (and correct for, if necessary) the impact of the 'Net' data in MDM format
3. A subset of NMIs with different characteristics (with and without solar PV and controlled load) to cross check the AEMO data.

The count of NMIs provided by each of the DNSPs is presented in **Table 35** below.

**Table 35:** DNSP data request

| DNSP | Count |
|---|---|
| Endeavour | 160 |
| Essential | 156 |
| EvoEnergy | 177 |
| Energex | 165 |
| Ergon | 72 |
| SAPN | 202 |
| TasNetworks | 340 |
| Ausgrid, Citipower, Powercor, United, Jemena | NA |

*Source: Frontier Economics*

[15] The AER contacted the DNSPs operating under the NERL (which excludes Victoria) to request participation in the project and agreement to provide consumption data. All DNSPs agreed to participate, however Ausgrid accepted an option to defer participation by six months. The AER did not contact Victorian DNSPs which are not legally obligated to provide data for benchmarking in order to limit regulatory burden. Our data request was therefore sent to all DNSPs except for Ausgrid and Victorian DNSPs.

Including the DNSP data, we received consumption data for 6,547 NMIs, a match rate of approximately 94%. However, of the 423 NMIs which did not match, 97 are Ausgrid NMIs confirmed by AEMO as valid NMIs, and a further 7 are Victorian NMIs confirmed by AEMO as valid. As outlined above we did not collect data from these DNSPs which pushes down the match rate.

In the data request to DNSPs, we requested that data be provided in NEM12 (for interval meters) or NEM13 (for accumulation meters) format. These formats are described in detail in a separate AEMO document.[16] All DNSPs provided data in these formats with the exception of EvoEnergy, which requested that it be allowed to provide data in a simpler bespoke format. In limited instances we had to make follow up data requests to DNSPs.

Again, there are some important characteristics of the NEM12 and NEM13 formats which are different to the MDM format of the data provided by AEMO that are relevant to this study.

- **Interval data (NEM12)**. In the NEM12 data format, each datastream is labelled with a suffix, and tagged explicitly as either an 'Export' or 'Import' (rather than relying on the sign of the reading). For this study, the most material difference to the MDM format is that Imports are clearly distinguished from Exports during all time intervals – even when both occur in the same time interval.
- **Accumulation data (NEM13).** In the NEM13 Format, accumulation meter data is presented separately for each datastream. For accumulation meters, the main difference to MDM format is that datastreams are explicitly tagged as being an 'Import' or 'Export' stream. It contains the same datastream suffix labelling as MDM format.

We submitted a final data request to each DNSP for a mapping of the datastream suffixes used in the NEM13 and MDM accumulation formats. All DNSPs provided sufficient guidance on this to identify datastreams in the accumulation data.

## Cleaning and processing electricity data

Since electricity consumption varies considerably by season, we estimated separate benchmarks for each season. Before producing the benchmarks, it was necessary to clean the raw metering data obtained from AEMO and the DNSPs, and process it to produce estimates of seasonal consumption. There are a number of ways that electricity consumption can be calculated or presented. This is particularly true for households with solar PV or other form of local generation which allows them to off-set some or all of their consumption at certain times of the day. For the purpose of this benchmarking study the relevant measure is the gross import by the household from the grid. This is effectively the electricity they must purchase from their retailer. Excess generation which they export to the grid, possibly on a feed-in-tariff (FiT), is separate to this. Essentially, processing the raw data to produce estimates of seasonal consumption involved the following steps:

- Identifying all data streams representing 'Import' values for each household and aggregating these.

[16] AEMO, 2017, *Meter Data File Format Specification NEM12 & NEM13*. Online at https://aemo.com.au/-/media/files/electricity/nem/retail_and_metering/metering-procedures/2018/mdff-specification-nem12--nem13-v106.pdf?la=en&hash=B35C40738FE79F8B6FCE3D00D2B26408

- Reconciling AEMO data and DNSP data.
- Allocating accumulation meter consumption data to a season based on the number of days in the read period that fall within each season.
- Matching the electricity consumption data to the respondents in the survey data.

There are a few elements of this which are important to describe in further detail.

**MDM data and 'Net' consumption**

As outlined in Section 2.1, MDM format data provided by AEMO for interval meters is a 'Net' value, with intervals of Export designated by a negative read. It is necessary to construct estimated 'Imports' from the Net data. To construct the estimated Import from the Net MDM data we designated any positive or zero readings as 'Import' and any negative readings as 'Export'.

However, as outlined below there is a small inaccuracy in the estimated Imports for customers with solar PV. The NEM12 format data provided by DNSPs presents Import and Export channels separately and therefore has no inaccuracy.

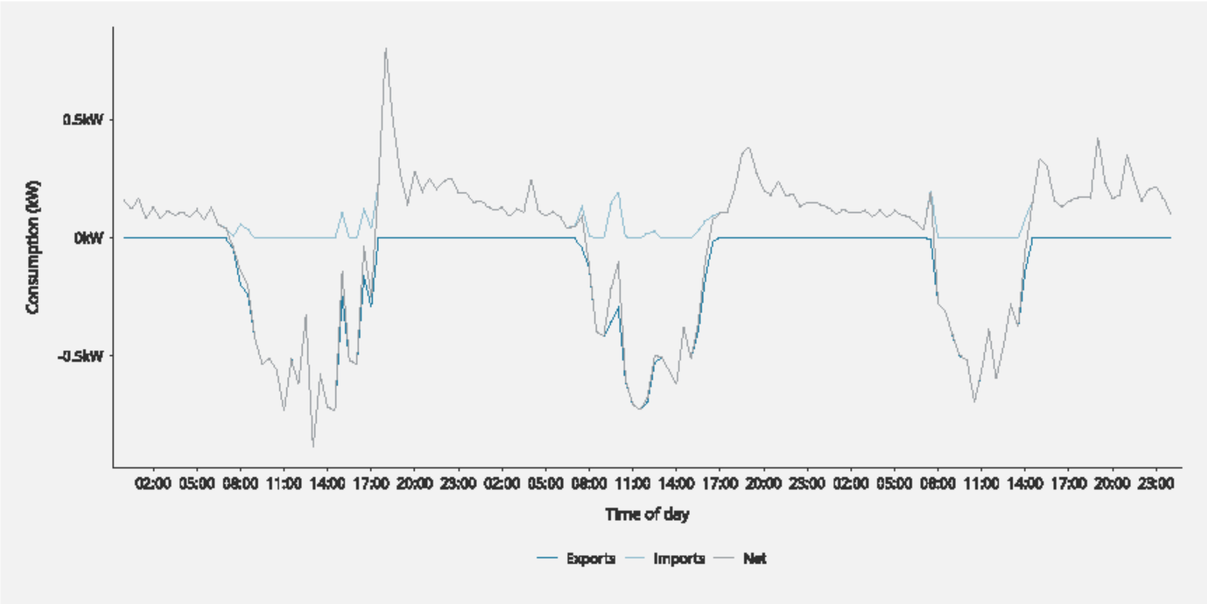
To mitigate this issue, we collected NEM12 format data from DNSPs for each household with an interval meter and solar PV. We use the NEM12 format data for all households where we have both formats. However, as we didn't collect NEM12 data from Ausgrid or Victorian DNSPs we had to use the constructed Import series from the MDM data for interval metered households in these networks.

For interval meters customers without solar PV, the estimated Import from the MDM format data effectively aligns with the Import from the NEM12 format data. Net consumption measurements in the MDM format are non-negative in each interval and can effectively be read directly as Import.

For interval meters with solar PV, there is a small loss of detail in the MDM format relative to the NEM12 format. Most households, in most intervals, record either Import or Export – not both. In these cases the two formats align. However, in some instances, households both Import and Export during the same thirty-minute interval. For example, a household which Imports 1kWh, and Exports 1kWh during an interval would record 'Net' consumption of 0kWh in the MDM Format and therefore also 0kWh in the estimated Import series. However, the true Import, as captured accurately in the NEM12 format is 1kWh. The estimated Import series is therefore lower than the actual Import, which is captured accurately in NEM12 format. The extent of the inaccuracy depends on the frequency with which Import and Export occur in the same thirty-minute interval, and the typical magnitude of Export during those intervals.

A de-identified example from the dataset demonstrating a period in which Import and Export occurs in the same interval, and the impact on 'Net' consumption is presented in **Figure 23** below.

**Figure 23**: Import and export in same period




*Source:* Frontier Economics analysis of AEMO, DNSP data

The chart covers a period of three days, starting at midnight of the first day on the far left. On the first day, solar PV exports start at around 8am and continue through to approximately 6pm. During this entire period, 'Net' consumption from the MDM data is less than zero, i.e. solar PV generation in each half hour interval between 8am and 6pm exceeds consumption by the household. However, there are four intervals during the day, at the start and end of the solar PV generation period, in which the customer has both Imports and Exports. Over the following two days, there are several similar instances.

This issue only applies to a small group of households – those in Ausgrid and Victoria with an interval meter and solar PV. To estimate the likely size of the issue we compared aggregate NEM12 Import with the constructed MDM Import series for interval meter customers with solar PV where we have both data sets. The comparison is presented in **Table 36** below.

**Table 36:** NEM12 and MDM data comparison for households with interval meter and solar PV

| State / Territory | Count | NEM12 Import in 2019 (kWh) | MDM constructed Import in 2019 (kWh) | Difference (%) |
|---|---|---|---|---|
| ACT | 15 | 4836 | 4707 | -2.7% |
| NSW | 211 | 5259 | 5131 | -2.4% |
| QLD | 162 | 4905 | 4779 | -2.6% |
| SA | 2 | 11243 | 11084 | -1.4% |
| TAS | 22 | 8228 | 7989 | -2.9% |
| VIC | NA | NA | NA | NA |

*Source: Frontier Economics analysis of AEMO, DNSP data*

Overall, for this subset of customers, the average estimated Import calculated from the MDM data is lower than the direct Import from the NEM12 data in all regions for which we have both. The difference ranges from approximately 1.4% (in South Australia, only based on only 2 households) to 2.9%, with an average of about 2.5%.

The consumption estimates for households with an interval meter and solar PV in the Ausgrid network or in Victoria are likely to have a small downwards bias of a similar magnitude. On balance, we decided not to attempt to correct for this, driven by two factors:

- The estimated difference is relatively small (about 2.5%) and applies only to the subset of households with an interval meter and solar PV.
  - In the Ausgrid region, this is 238 of 1,252 households (about 19%)
  - In Victoria this is 523 of 1,700 households (about 31%)
  - Taken together, this would imply a difference in aggregate consumption across all households of less than 1%
- We can't be sure whether the magnitude of the bias is similar in Ausgrid and Victoria as in other regions, so can't be confident that an attempted correction would result in more accurate estimates of consumption.

**Reconciling AEMO and DNSP data**

For some households in the sample, we were provided consumption data from AEMO only (in MDM format). For others, we were provided data by DNSPs only (in NEM12 or NEM13 formats). For the remainder we were provided data by both AEMO and DNSPs (or neither). Where we had data from both sources, it was important to compare and reconcile the values from the two data sources. Broadly, this entailed:

- For interval data: Testing that the date, time and consumption values were consistent across the two datasets in each thirty-minute interval. We constructed a 'Net' value from the DNSP NEM12 data to reproduce the corresponding value from the AEMO MDM format dataset.

- For accumulation data: Testing that the dates and read values were consistent across the two datasets for each meter read. We also tested the consistency of datastream suffix use between the two datasets and with the suffix mapping provided by DNSPs.

Overall, we found the two data sources were highly consistent, and for nearly all households we could reconcile the two data sources. There were a few minor exceptions. A small number of households had missing values in one dataset, which were not missing in the other. A few households with interval data had similar but slightly different read values for a subset of intervals (not material when aggregated to a seasonal value). In general, we gave primacy to the DNSP dataset to resolve any outstanding differences.

**Allocating consumption data to seasons**

The AER's requirement is to develop 'seasonal' consumption benchmarks. Following the convention from the previous benchmarks we define the seasons as being comprised of the following months:

- Summer: December, January, February
- Autumn: March, April, May
- Winter: June, July, August
- Spring: September, October, November.

For interval meter data, allocating electricity consumption data to season is simple. For allocation meter data it is usually the case that a meter read period covers multiple seasons. Therefore, we needed to allocate consumption for these reads between the relevant seasons. Our approach was as follows:

1. Calculate the total number of days in the meter read period, and the number of days that fall into each season.
2. Calculate average daily consumption for the meter read period.
3. For each meter read and season, multiply the average daily consumption over the read period by the number of days of the read that fall in the season.

If, for a given household, the total number of days in a season obtained by this method across all meter reads was below 15, it was considered insufficient for estimating the season's total consumption for this household and the household was not included in the final dataset for the season. If the total number of days exceeded 15, but was lower than the total number of days in the season, the total consumption was inflated proportional to the number of missing days.

**Matching to the survey data**

The seasonal electricity consumption values were matched to the survey data using the NMI to produce the final dataset for analysis. We excluded any respondents that indicated that they run a business from home that consumes a large amount of electricity.

**Final sample cleaning**

A small number of respondents were removed from the final electricity benchmark sample. This included:

- 78 households that reported running an energy intensive business from their home

- 4 households that reported living in a location that was inconsistent with their NMI, for example a household in metropolitan Sydney that provided a South Australian NMI.

## Collecting gas consumption data

Survey respondents who indicated that they had a mains gas connection were asked to provide their MIRN. We used the MIRN to match survey responses with gas consumption data. As outlined in Section 2.1, respondents were warned three times if they entered a MIRN that appeared to be invalid. However, if they persisted with an invalid MIRN they were allowed to continue with the survey.

Gas consumption data was collected directly from gas distribution networks. All gas networks agreed to participate in the benchmarking and provide data.

To our knowledge, there is no standardised format for gas metering data used across gas networks (in the way that electricity data formats are standardised by AEMO), so we requested that the gas networks follow a simple template that we developed.

We requested data for 3,370 MIRNs and received data for 3,163, a match rate of approximately 94%.

## Cleaning and processing gas data

Similarly to the electricity data, it was necessary to clean and process gas data to produce seasonal consumption totals. Gas consumption data is simpler than electricity consumption data. For example, all data is accumulation meter data, there are not separate metering channels for each customer, and gas flows in only one direction – from the grid to the customer.

However, there are a few features of the gas consumption data processing worth describing.

**Interim and estimated reads**

The gas consumption dataset contained a substantial proportion of 'estimated' reads. These occur when the gas network has not completed a physical meter read for a customer, but requires an estimate of gas consumption for billing purposes. Estimated reads are much more common for gas consumption than electricity consumption. Approximately 8% of reads in our dataset were estimated reads. Broadly, there appear to be two reasons for estimated reads in the dataset:

1. If the gas network is not able to complete a meter read for the billing cycle. For example, if the meter reader is not able to access the meter for any reason.
2. To provide an interim read for more frequent billing between actual reads. For example, it appears that TasGas Networks generally estimates a meter read each month for billing and completes an actual read every three months.

Most of the time, the estimated reads appear reasonably accurate with the benefit of hindsight. However, in some cases, they are very inaccurate. In particular, it is not uncommon for estimated reads to far exceed underlying consumption. If this occurs, the value on the next actual meter read may be below the previous estimated read. In such cases, the consumption on the estimated read is entered as a negative value to true up.

In other cases, the estimated read may be replaced by a 'self read' provided by a customer to the gas network. In these cases, the estimated read is negated (by a corresponding negative value of the same magnitude), and replaced shortly afterwards by an alternative value – presumably that provided by the consumer.

It isn't clear to us how gas networks calculate estimated reads. We understand it is based on a combination of average characteristics of consumers in the network, and consumer-specific characteristics. Estimated reads are useful for allowing a gas network to bill customers in the absence of timely actual consumption data. However, for the purposes of estimating seasonal consumption values, estimated reads and true-ups can lead to unstable values. For example, a series of inaccurately high estimated reads could lead to an estimate of very high consumption through Winter (based on estimated reads), followed by very low or negative consumption in Spring (based on the true-ups). A series of inaccurately low estimated reads could lead to the opposite. Unlike the networks, we effectively have the benefit of hindsight as we can see observe each actual read. This allows us to estimate consumption without needing to use the estimated reads.

To develop the seasonal consumption values, we only have regard for the actual reads. For example suppose an actual read was taken on the 1st of January, followed by an estimated read with consumption of 1,000MJ on the 1st of February, an estimated read with consumption of 1,000MJ on the 1st of March, and an actual read with consumption of 400MJ on the 1st of April (for a total of 2,400MJ over the three months). We would only consider the actual reads on the 1st of January and the 1st of April with consumption of 2,400MJ for the three months. Each seasonal consumption estimate in our constructed dataset is non-negative.

**Allocating consumption data to seasons**

To develop seasonal gas benchmarks it is necessary to allocate the gas consumption data to each season. The seasons are defined the same way as for the electricity benchmarks.

Broadly we adopt the same method that we used to allocate electricity accumulation meter data to season. However, as outlined above, this is based on our constructed series of 'actual' reads, and doesn't consider the timing and magnitude of any estimated reads.

As with electricity, if for a given household, the total number of days in a season obtained by this method across all meter reads was below 15, it was considered insufficient for estimating the season's total consumption and the household was not included in the final dataset for the season. If the total number of days exceeded 15, but was lower than the total number of days in the season, the total consumption was inflated proportional to the number of missing days.

**Matching to the survey data**

The seasonal gas consumption values were matched to the survey data using the MIRN to produce the final gas dataset for analysis.

**Final sample cleaning**

A small number of respondents were removed from the final gas benchmark sample. This included 15 respondents for which the metered gas consumption was 0 in every period.

# B Electricity consumption benchmark methodology

This technical appendix sets out additional detail on our approach to estimating electricity consumption benchmarks, and model selection in each climate zone.

## Summary of approach

### Final data cleaning

We removed some outliers from the electricity dataset before developing the consumption benchmarks. This involved removing:

- Observations with electricity consumption of <100kWh for a season. We consider that this level of consumption would be too low for a typical residential lifestyle. For example, it generally wouldn't be sufficient to power a small fridge and household lights, even if no other electric appliances were used in the house. While it may be technically possible for a small household with a large solar panel and battery to consume such a small amount from the grid, such a household would operate effectively as off-grid, and hence would not be representative of typical grid connected households.
- Observations with electricity consumption greater than 15MWh in a season. We also examined the consumption pattern for any household with electricity consumption greater than 10MWh in a season on a case-by-case basis. For these observations, we considered whether the high consumption appeared to be reasonably explained by characteristics of the dwelling, appliance stock, or behaviour. We exercised professional judgement on whether to include or exclude the observation.

### Base model and pooling

The electricity consumption benchmarks for each climate zone do not include any explanatory benchmark factors other than household size. However, the benchmark models prepared for 2020 enable additional factors to be considered for broader purposes, such as more detailed consumption benchmarks for the EME website.

As outlined in Section 3, the sample size in Climate Zone 3 is small (at 13 households). This is too small to independently estimate benchmarks. We pooled the households in Climate Zone 3 with Climate Zone 1, which is the closest geographically and has the most similar climate. This ensured a minimum sample size of at least 15 for each household size.

A number of climate zones cross multiple jurisdictions – for example, Climate Zone 4 crosses South Australia, New South Wales and Victoria. In these climate zones it is possible to estimate a separate set of benchmarks for each climate zone / jurisdiction combination or to pool households of the same size across jurisdictions. At times pooling is useful to improve the statistical properties of the estimated benchmarks.

In general, the starting point for each climate zone was to estimate a model that included all households within the climate zone, but with separate dummy variables for each household size within each state. For example for Climate Zone 4 this starting model would include 15 variables (household sizes 1-5+ in South Australia, 1-5+ in New South Wales, and 1-5+ in Victoria). We also considered 'pooled' models that combined households from different jurisdictions within the climate zone and estimated common benchmarks for each household size. We would test the reasonableness of the pooled models by conducting F-tests to assess whether the coefficients on the same household size across states were statistically significantly different or not.

In some cases there are 'backwards steps' in electricity consumption, where average consumption is lower for a larger household size than a smaller one. This is not necessarily implausible. There are a number of drivers of household electricity consumption, the number of people in the dwelling being just one of these. However such backward steps would be confusing for retail customers.

Where backward steps occurred, we undertook further investigations to determine whether the results could be due to imprecise estimates driven by small sample sizes or highly variable seasonal consumption between households. Where appropriate, we tested alternate models with pooled household sizes (pooling the sizes together where backwards steps occur). We used F-tests to test whether the consumption differences between the two household sizes were statistically significant. If the F-test found that the household sizes could not reasonably be pooled, we would select the statistically preferred model even if it included a backwards step.[17] If the F-test found the household sizes could reasonably be pooled, we would select the model with no backwards step in consumption.

We tested a number of different models within each climate zone with different pooling options between jurisdictions and household sizes to select a preferred model. This necessarily involved professional judgement; however, we were guided by a number of criteria, such as:

- Maximising the explanatory power of the model according to the adjusted $R^2$ criterion, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The AIC and BIC criteria penalise more complex models that have additional variables.
- Reducing the number of backwards steps by pooling across household sizes where possible.

## Weighting the sample

As discussed in Section 3.3.3, the sample is overrepresented with respect to households with solar PV, and slightly overrepresented with respect to households with mains gas. This potentially poses an issue for the consumption benchmarks if households with solar PV or with mains gas tend to consume a different level of electricity than households without. For example, if households with solar PV tend to consume less electricity than those without, a benchmark based on the simple sample average of consumption would be biased downward due to the overrepresentation of solar PV households.

In general, the simplest approach to manage a difference between households with and without solar PV (or mains gas) is to include it as a benchmark factor and present a consumption benchmark for households with and without. This would explicitly capture and account for the difference. However, this isn't possible for the simple consumption benchmarks for inclusion on retail bills.

[17] Note that this did not occur in any of the final electricity benchmark model specifications.

Therefore we included a dummy variable for solar PV and for mains gas in the consumption benchmark models. We evaluated the models at the jurisdictional average proportions of households with solar PV and mains gas.

## Summary of results

### Climate Zones 1 and 3

The sample includes 167 households in Climate Zone 1, which covers a large area of far North Queensland. Much of Climate Zone 1 is neighboured by Climate Zone 3, which covers a vast but sparsely populated area of inland Queensland. The sample contained only 13 respondents from Climate Zone 3. This is too few households to estimate robust benchmarks for Climate Zone 3. Pooling Climate Zones 1 and 3 ensured a minimum sample size of 15 households of each size.

We tested several approaches to combining Climate Zones 1 and 3 in the same model. We found that households in Climate Zone 3 generally had higher average consumption than households in Climate Zone 1, but that this was not very robust due to the small sample sizes. So we pooled Climate Zones 1 and 3 together. This was supported by an F-test on the household size dummy variables across climate zones and on climate zone dummy variables.

The electricity consumption benchmarks for Climate Zones 1 and 3 were estimated using the base model.

$$Consumption = b_1 HH_1 + b_2 HH_2 + b_3 HH_3 + b_4 HH_4 + b_5 HH_5 + b_6 PV + b_7 MainsGas + \epsilon$$

In summer, there was a small backwards step in consumption between 4 and 5+ person households. We tested whether these household sizes could be pooled, which was supported by an F-test on the individual household size dummy variables.

We found that households with solar PV and mains gas had lower electricity consumption on average than households without in all seasons and evaluated the benchmarks at the state population average for these factors.

### Climate Zone 2

The sample includes 1,291 households in Climate Zone 2. The majority of these, 1,177, are in Queensland. Climate zone two includes several major urban centres in Queensland including Brisbane and the Gold Coast. The remaining 114 households are in northern New South Wales.

We tested a number of models for the basic consumption benchmarks in Climate Zone 2. We found that consumption was similar between Climate Zone 2 households of the same size across Queensland and New South Wales. Therefore, we pooled the two states in the same model for Climate Zone 2. This was supported by an F-test on the household size dummy variables across states and on state dummy variables.

The electricity consumption benchmarks for Climate Zone 2 were estimated using the base model.

$$Consumption = b_1 HH_1 + b_2 HH_2 + b_3 HH_3 + b_4 HH_4 + b_5 HH_5 + b_6 PV + b_7 MainsGas + \epsilon$$

We found that households with solar PV and mains gas had lower electricity consumption on average than households without in all seasons and evaluated the benchmarks at the state population average for these factors.

## Climate Zone 4

The sample includes 198 households in Climate Zone 4. The majority of these, 127, are in New South Wales, with 53 in Victoria and 18 in South Australia. Climate Zone 4 covers a wide and sparsely populated region across inland New South Wales, north west Victoria and northern South Australia.

We tested a number of models for the electricity consumption benchmarks in Climate Zone 4. We found that consumption was relatively similar between the states in Climate Zone 4. Therefore we pooled all three states in the same model. This was supported by an F-test on the household size dummy variables across states and on state dummy variables.

There were some small backwards steps between 3, 4 and 5+ person households in all model specifications. We tested whether these household sizes could be pooled. The pooling was supported by an F-test on the individual household size dummy variables in all seasons. Therefore we pooled households with 3 or more people.

The electricity consumption benchmarks for Climate Zone 4 were estimated using the base model.

$$Consumption = b_1HH_1 + b_2HH_2 + b_3HH_{3,4,5} + b_4PV + b_5MainsGas + \epsilon$$

We found that households with solar PV had lower electricity consumption on average than households without in all seasons. We found that households with gas consumed less electricity on average than households without in winter, but that consumption was similar in the other seasons. We evaluated the benchmarks at the state population average of these factors in all seasons.

## Climate Zone 5

The sample includes 1,908 households in Climate Zone 5. This includes 1,329 in New South Wales and 505 in South Australia. Climate Zone 5 covers several metropolitan areas including greater Sydney and Adelaide. The remaining 64 are in Queensland, in a small pocket to the immediate west of Brisbane.

We tested a number of models for the electricity consumption benchmarks in Climate Zone 5. Despite the geographic separation of Climate Zone 5 across states, we found that consumption for each household size was similar between states. We pooled households from all three states together in the same model. This was supported by F-tests on the household size dummy variables across states and on state dummy variables.

The electricity consumption benchmarks for Climate Zone 5 were estimated using the base model.

$$Consumption = b_1HH_1 + b_2HH_2 + b_3HH_3 + b_4HH_4 + b_5HH_5 + b_6PV + b_7MainsGas + \epsilon$$

We found that households with solar PV had lower consumption on average than households without in spring, summer and autumn, but that there was no meaningful difference in winter. We found that households with mains gas had lower electricity consumption on average than households without in all seasons. We evaluated the benchmarks at the state population averages of these factors in all seasons.

## Climate Zone 6

The sample includes 2,108 households in Climate Zone 6, which is the highest number in any climate zone. Of these, 1,474 are in Victoria, with Climate Zone 6 covering metropolitan Melbourne as well as a number of large regional centres. A further 547 are in New South Wales, and the remaining 87 are in South Australia.

Like the other climate zones that cross over multiple states we tested a number of models for the electricity consumption benchmarks in Climate Zone 6. We found that consumption in Victoria and South Australia was similar in all seasons, but that consumption in New South Wales was significantly higher in all seasons.

Therefore we pooled households in Victoria and South Australia. This was supported by an F-test on the household size dummy variables and state dummy variables across these two states. Pooling New South Wales with the other states was rejected by the F-test. Therefore we included all of the households in Climate Zone 6 in the same model, but estimated separate benchmarks for each household size in New South Wales.

The electricity consumption benchmarks for Climate Zone 6 were estimated using the base model.

$$\begin{aligned} Consumption = {} & b_1 SAVICHH_1 + b_2 SAVICHH_2 + b_3 SAVICHH_3 + b_4 SAVICHH_4 + b_5 SAVICHH_5 \\ & + b_6 NSWHH_1 + b_7 NSWHH_2 + b_8 NSWHH_3 + b_9 NSWHH_4 + b_{10} NSWHH_5 + b_{11} PV \\ & + b_{12} MainsGas + \epsilon \end{aligned}$$

In summer, there was a small backwards step in consumption between 3 and 4 person households. We tested whether these household sizes could be pooled, which was supported by an F-test on the two individual household size dummy variables.

We found that households with solar PV and mains gas had lower electricity consumption on average than households without in all seasons and evaluated the benchmarks at the state population average for these factors.

## Climate Zone 7

The sample includes 770 households in Climate Zone 7, spread across four states and territories. There are 342 households in Tasmania, which is entirely within Climate Zone 7, 203 in the ACT which is also entirely in climate 7 and a further 167 and 68 respondents in the alpine regions of Victoria and New South Wales respectively.

Again, we tested a number of models to assess how best to account for the different states and territories that span Climate Zone 7, with particular consideration given to Tasmania given its physical separation from the rest of the NEM and much higher than average electricity consumption.

We found that consumption in neighbouring New South Wales and the ACT was similar. Therefore we pooled households in New South Wales and the ACT. This was supported by an F-test on the household size dummy variables and state dummy variables across these two regions.

However, we found that electricity consumption in Tasmania was significantly higher than those regions, and that electricity consumption in Victoria was significantly lower than those regions. Any pooling of the Tasmanian and/or Victorian regions with New South Wales/ACT was rejected by F-tests. Therefore we included all of the households in Climate Zone 7 in the same model, but estimated separate benchmarks for each household size in Tasmania and in Victoria.

The electricity consumption benchmarks for Climate Zone 7 were estimated using the base model.

$$\begin{aligned} Consumption = \; & b_1 ACTNSWHH_1 + b_2 ACTNSWCHH_2 + b_3 ACTNSWHH_3 + \; b_4 ACTNSWHH_4 \\ & + b_5 ACTNSWVICHH_5 + b_6 TASHH_1 + b_7 TASHH_2 + b_8 TASHH_3 + \; b_9 TASHH_4 \\ & + b_{10} TASHH_5 + b_{11} VICHH_1 + b_{12} VICHH_{2,3,4} + b_{13} VICHH_5 + b_{14} PV + b_{15} MainsGas + \epsilon \end{aligned}$$

In all seasons in Victoria, there were some small backwards steps in consumption between 3, 4 and 5+ person households. We tested whether these household sizes could be pooled, which was supported by an F-test on the individual household size dummy variables.

We found that households with solar PV had lower consumption on average than households without in spring, summer and autumn, but that there was no meaningful difference in winter. We found that households with mains gas had lower electricity consumption on average than households without in all seasons. We evaluated the benchmarks at the state population averages of these factors in all seasons.

# C Gas consumption benchmark methodology

This technical appendix sets out additional detail on our approach to estimating gas consumption benchmarks, and model selection in each state and territory.

## Summary of approach

### Base model

The gas consumption benchmarks do not include any explanatory factors. However, we developed the models to allow for additional factors for broader purposes such as developing detailed consumption benchmarks for the EME website.

As outlined in Section 3 the gas sample size in Tasmania is only 18 households, which is too small to independently estimate benchmarks. We considered that the most appropriate treatment was to pool Tasmania and the ACT to develop gas benchmarks. Gas consumption in the ACT was most similar to Tasmania, and they share the most similarity in climate zones at the jurisdiction level. We also considered pooling Tasmania with Victorian households, however the ACT was a closer fit. This ensured a minimum sample size of at least 15 for each household size.

As in the electricity benchmarks, sometimes there are 'backwards steps' in gas consumption, where the gas consumption for a larger household is less than for a smaller household. Overall, we managed backwards steps and pooling in the same manner as for the electricity consumption benchmarks. Where backward steps occurred, we undertook further investigations to determine whether the results could be due to imprecise estimates driven by small sample sizes or highly variable seasonal consumption between households. Where appropriate, we tested alternate models with pooled household sizes (pooling the sizes together where backwards steps occur), using F-tests to test whether the consumption differences between the two household sizes were statistically significant. If the F-test found that the household sizes could not reasonably be pooled, we selected the statistically preferred model even if it included a backwards step.[18] If the F-test found the household sizes could reasonably be pooled, we selected the model with no backwards step in consumption.

We tested a number of different models within each jurisdiction to select a preferred model. This necessarily involved professional judgement; however, we were guided by a number of criteria, such as:

- Maximising the explanatory power of the model according to the adjusted $R^2$ criterion, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The AIC and BIC criteria penalise more complex models with additional variables.
- Reducing the number of backwards steps by pooling across household sizes where possible.

[18] Note that this did not occur in any of the final gas benchmark model specifications.

# Summary of results

## ACT and Tasmania

The sample includes only 18 households from Tasmania in the gas sample. This is too few households to independently develop gas consumption benchmarks for Tasmania. For example, there are no households with 5 or more people in Tasmania with gas in the sample. Hence we investigated pooling Tasmania with either Victoria or the ACT, the two jurisdictions with the most similar climate to Tasmania. The gas sample includes 1,380 households in Victoria and 162 households in the ACT.

We tested several approaches to combining Tasmania with Victoria or the ACT in the same model. We found that consumption in Victoria was significantly higher than in Tasmania and pooling Tasmania and Victoria were rejected by F-tests.

However, we found that while gas consumption in the ACT was higher on average than in Tasmania, it was not by a significant margin. Hence we pooled Tasmania and the ACT together in the same model. This was supported by an F-test on the household size dummy variables across the two jurisdictions and on jurisdiction dummy variables.

The gas consumption benchmarks for ACT and Tasmania were estimated using the base model:

$$Consumption = b_1HH_1 + b_2HH_2 + b_3HH_3 + b_4HH_4 + b_5HH_5 + \epsilon$$

There were a small number of backwards steps in some seasons in the base model. We tested whether 2 and 3 person households could be pooled in autumn, winter and spring, and whether 4 and 5 person households could be pooled in autumn and summer. In all cases, this pooling was supported by an F-test on the household size dummy variables. Therefore we selected the pooled models to estimate the benchmarks.

## New South Wales

The gas sample includes 1,062 households in New South Wales. The gas consumption benchmarks for New South Wales were estimated using the base model:

$$Consumption = b_1HH_1 + b_2HH_2 + b_3HH_3 + b_4HH_4 + b_5HH_5 + \epsilon$$

There was no pooling across households in any of the seasons.

## Queensland

The gas sample includes 153 households in Queensland. The gas consumption benchmarks for Queensland were estimated using the base model:

$$Consumption = b_1HH_1 + b_2HH_2 + b_3HH_3 + b_4HH_4 + b_5HH_5 + \epsilon$$

There was no pooling across households in any of the seasons.

## South Australia

The gas sample includes 373 households in South Australia. The gas consumption benchmarks for South Australia were estimated using the base model:

$$Consumption = b_1HH_1 + b_2HH_2 + b_3HH_3 + b_4HH_4 + b_5HH_5 + \epsilon$$

There were a number of small backwards steps in the benchmarks for larger household sizes in autumn, winter, and spring. We tested pooling 3, 4 and 5 person households in winter and spring, and 3 and 4 person households in autumn. The pooling of those households in those seasons was supported by F-tests on the household size dummy variables. Therefore we selected the pooled models to estimate the benchmarks.

## Victoria

The gas sample includes 1,380 households in Victoria. The gas consumption benchmarks for Victoria were estimated using the base model:

$$Consumption = b_1 HH_1 + b_2 HH_2 + b_3 HH_3 + b_4 HH_4 + b_5 HH_5 + \epsilon$$

There were a number of small backwards steps in the benchmarks for 2 and 3 person households in autumn, winter, and spring. We tested pooling 2 and 3 person households in those seasons. The pooling was supported by F-tests on the household size dummy variables. Therefore we selected the pooled models to estimate the benchmarks.

# D Household survey

1. Consent statement

- **Explanatory statement**

  This survey will be used by the Australian Government, to work out how much electricity and gas Australian households generally consume in a year. The results will help energy customers compare their energy use with similar households in their area, assisting them to manage energy use and their bills.

  The survey is being conducted for the Australian Energy Regulator (AER) by their consultants Frontier Economics.

  As part of completing this survey, you need to agree to have your electricity and (if relevant) gas consumption data released. In particular, we are seeking your consumption data for the past 18 months. This will be matched to the electricity/gas meter numbers you provide in this survey. If you agree, the Australian Energy Market Operator (AEMO) will release your electricity consumption data to the AER, which will be shared with Frontier Economics solely for the purposes of this project. If AEMO cannot provide consumption data for your meter number, Frontier Economics will request your electricity consumption data from your electricity distributor. Your gas consumption data will be released directly to Frontier Economics by your gas distributor.

  Frontier Economics will analyse your energy consumption together with your survey responses to develop the consumption benchmarks. Frontier Economics will provide the aggregated and de-identified outcomes of their analysis to the AER.

  The AER will then publish an anonymous dataset with the results of this project on its website. That dataset can then be used by members of the public, and by governments and researchers to inform energy policy. To protect your privacy the information you provide will be aggregated and de-identified. No individuals or households will be identifiable in the published dataset.

  More information on how the AER handles personal information can be found here https://www.accc.gov.au/privacy

- **Question:**

  Do you agree to the release of your:

  - electricity consumption data by AEMO or, if AEMO is unable to provide it, by your electricity distributor, and
  - gas consumption data by your gas distributor.

  to Frontier Economics and to the Australian Energy Regulator, understanding that your data will be anonymised before publication?

- **Response options:** Yes / No

2. Bill payer

- **Explanatory statement:** This survey asks a number of questions related to energy use in the residence that you live in. If you have a holiday home, or split time between locations, please answer each question as it relates to the residence that is your primary place of residence.
- **Question:** Do you contribute to paying the energy bill and/or decisions about using electricity and gas in the residence you live in?
- **Response options:** Yes / No

3. Postcode and suburb

- **Explanatory statement:** None
- **Question**
  a. What postcode is the residence in?
  b. What suburb is the residence in?
- **Response options**:
  a. 4 digit number
  b. Selection from a drop down box with suburb names from Australia Post postcode suburb mapping

4. Number of people

- **Explanatory statement**: None
- **Question**: How many people in total live in the residence?
- **Response options**: Free number entry

5. Length of residence

- **Explanatory statement**: None
- **Question**: When did you start living at this residence?
- **Response options**: Selection from year drop down and month drop down
- **Notes**: People who had been living in the household less than 18 months were filtered out of the survey at this point

6. Gas

- **Explanatory statement**: None
- **Question**: Does the residence have mains gas?
- **Response options**:

- Yes, there is a mains connected gas supply
- Yes, the residence has mains gas but I don't get a separate bill (it might be part of the strata fees for your apartment or similar)
- Yes, there is have bulk bottled gas that is piped into the residence (not just for BBQ)
- No

- **Notes**: People who indicated that they didn't have gas didn't receive later questions related to gas

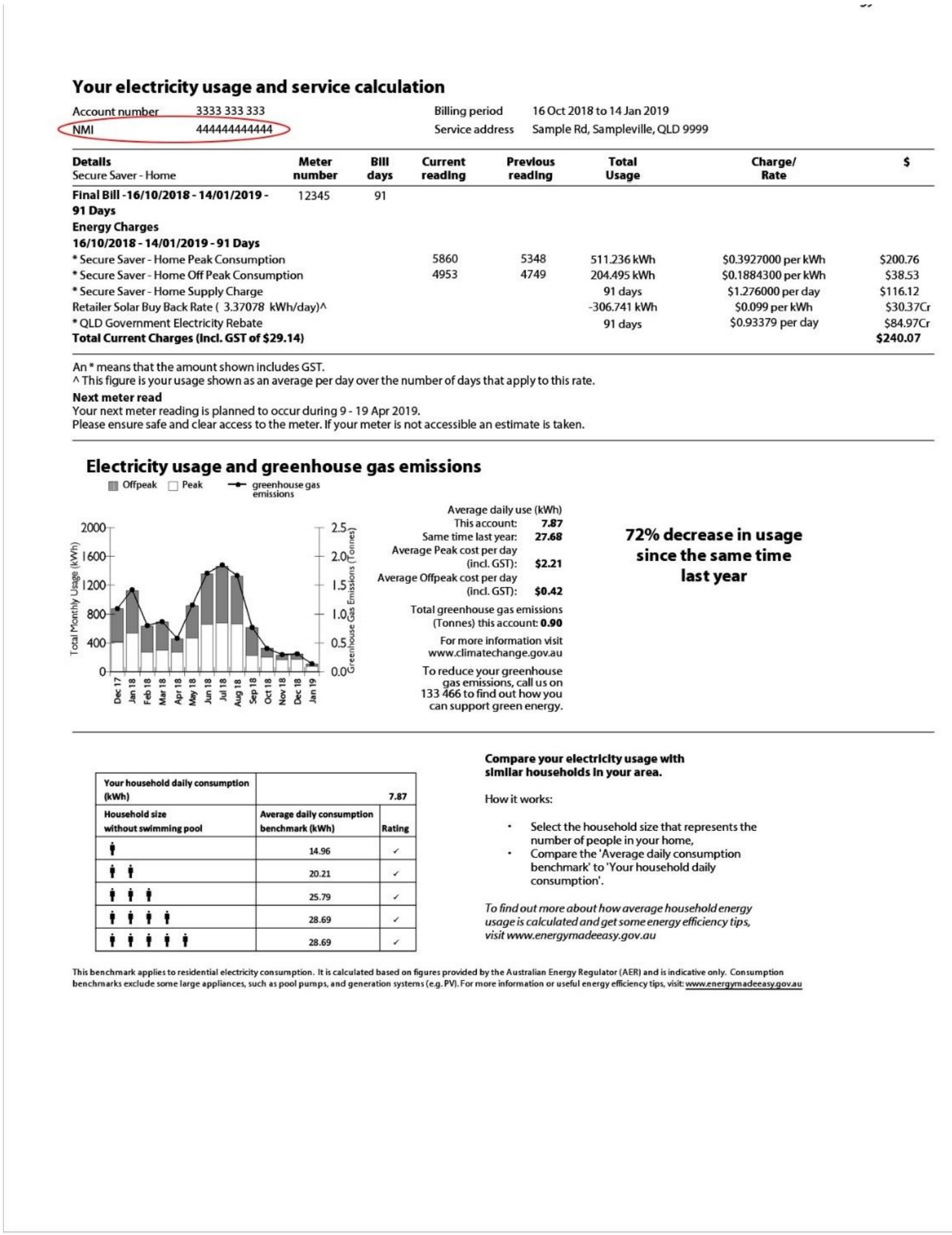
7. NMI

- **Explanatory statement**:
  **What is my NMI and how do I find it?**

  The NMI is on your electricity bill. It is a 10 or 11 digit number, possibly including letters. It is not your account number or your meter number.

  Your NMI will typically be on the front page of your bill, near your address, or the second page of your bill, near your meter read summary. This can vary from retailer to retailer, but every bill will have a NMI somewhere. If your bill was emailed to you, you may need to click through to your retailer's website to find your NMI.

  Here is a sample bill with the NMI highlighted to help you find it:



**Your electricity usage and service calculation**

Account number 3333 333 333
NMI 444444444444
Billing period 16 Oct 2018 to 14 Jan 2019
Service address Sample Rd, Sampleville, QLD 9999

| Details Secure Saver - Home | Meter number | Bill days | Current reading | Previous reading | Total Usage | Charge/ Rate | $ |
|---|---|---|---|---|---|---|---|
| **Final Bill -16/10/2018 - 14/01/2019 - 91 Days** | 12345 | 91 | | | | | |
| **Energy Charges** | | | | | | | |
| **16/10/2018 - 14/01/2019 - 91 Days** | | | | | | | |
| * Secure Saver - Home Peak Consumption | | | 5860 | 5348 | 511.236 kWh | $0.3927000 per kWh | $200.76 |
| * Secure Saver - Home Off Peak Consumption | | | 4953 | 4749 | 204.495 kWh | $0.1884300 per kWh | $38.53 |
| * Secure Saver - Home Supply Charge | | | | | 91 days | $1.276000 per day | $116.12 |
| Retailer Solar Buy Back Rate ( 3.37078 kWh/day)^ | | | | | -306.741 kWh | $0.099 per kWh | $30.37Cr |
| * QLD Government Electricity Rebate | | | | | 91 days | $0.93379 per day | $84.97Cr |
| **Total Current Charges (Incl. GST of $29.14)** | | | | | | | **$240.07** |

An * means that the amount shown includes GST.
^ This figure is your usage shown as an average per day over the number of days that apply to this rate.

**Next meter read**
Your next meter reading is planned to occur during 9 - 19 Apr 2019.
Please ensure safe and clear access to the meter. If your meter is not accessible an estimate is taken.

**Electricity usage and greenhouse gas emissions**



Average daily use (kWh)
This account: **7.87**
Same time last year: **27.68**
Average Peak cost per day (incl. GST): **$2.21**
Average Offpeak cost per day (incl. GST): **$0.42**
Total greenhouse gas emissions (Tonnes) this account: **0.90**
For more information visit www.climatechange.gov.au
To reduce your greenhouse gas emissions, call us on 133 466 to find out how you can support green energy.

**72% decrease in usage since the same time last year**

| Your household daily consumption (kWh) | | 7.87 |
|---|---|---|
| **Household size without swimming pool** | **Average daily consumption benchmark (kWh)** | **Rating** |
| 1 person | 14.96 | ✓ |
| 2 people | 20.21 | ✓ |
| 3 people | 25.79 | ✓ |
| 4 people | 28.69 | ✓ |
| 5 people | 28.69 | ✓ |

**Compare your electricity usage with similar households in your area.**

How it works:

- Select the household size that represents the number of people in your home,
- Compare the 'Average daily consumption benchmark' to 'Your household daily consumption'.

*To find out more about how average household energy usage is calculated and get some energy efficiency tips, visit www.energymadeeasy.gov.au*

This benchmark applies to residential electricity consumption. It is calculated based on figures provided by the Australian Energy Regulator (AER) and is indicative only. Consumption benchmarks exclude some large appliances, such as pool pumps, and generation systems (e.g. PV). For more information or useful energy efficiency tips, visit: www.energymadeeasy.gov.au

- **Question**: Please enter your NMI (National Meter Identifier). Please take care doing this. It is very important for the study that this is accurate.
- **Response options**: Free entry, but with structural checks and numeric checksum
- **Notes:** People who entered an invalid NMI were provided further guidance on how to locate the NMI. If they were not able to enter a valid NMI they were not able to proceed with the survey

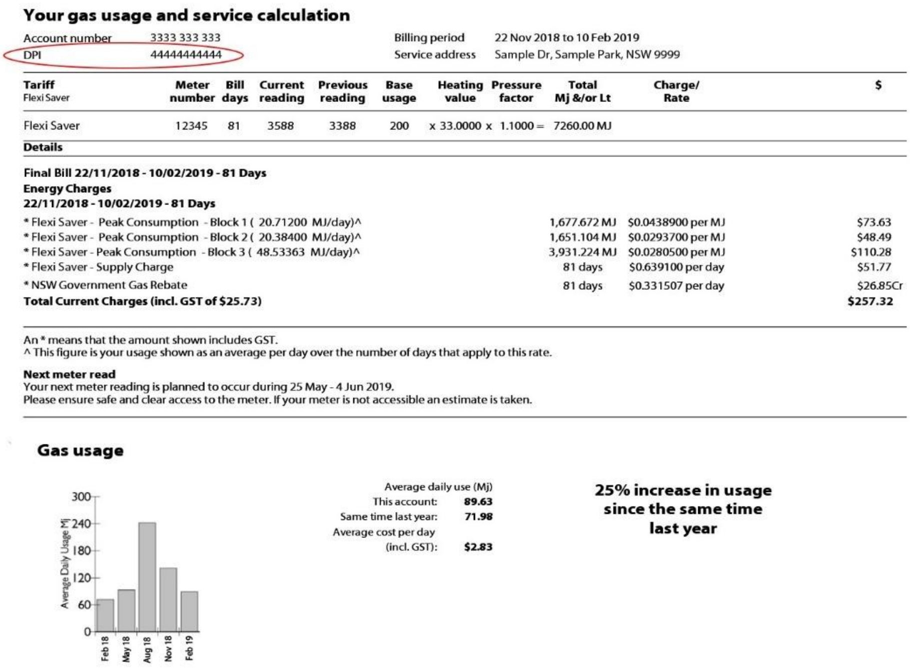
8. MIRN

- **Explanatory statement**:
- **What is my MIRN (or DPI) and how do I find it?**

The MIRN (or DPI) is on your gas bill. It is a 10 or 11 digit number. It is not your account number or your meter number.

Your MIRN (or DPI) will typically be on the front page of your bill, near your address, or the second page of your bill, near your meter read summary. This can vary from retailer to retailer, but every bill will have a MIRN or DPI somewhere. If your bill was emailed to you, you may need to click through to your retailer's website to find your MIRN (or DPI).

Here is a sample bill with the MIRN / DPI highlighted to help you find it



**Your gas usage and service calculation**

Account number 3333 333 333 | Billing period 22 Nov 2018 to 10 Feb 2019
DPI 44444444444 | Service address Sample Dr, Sample Park, NSW 9999

| Tariff Flexi Saver | Meter number | Bill days | Current reading | Previous reading | Base usage | Heating value | Pressure factor | Total Mj &/or Lt | Charge/ Rate | $ |
|---|---|---|---|---|---|---|---|---|---|---|
| Flexi Saver | 12345 | 81 | 3588 | 3388 | 200 | x 33.0000 x | 1.1000 = | 7260.00 MJ | | |

**Details**

**Final Bill 22/11/2018 - 10/02/2019 - 81 Days**
**Energy Charges**
**22/11/2018 - 10/02/2019 - 81 Days**

| | | | |
|---|---|---|---|
| * Flexi Saver - Peak Consumption - Block 1 ( 20.71200 MJ/day)^ | 1,677.672 MJ | $0.0438900 per MJ | $73.63 |
| * Flexi Saver - Peak Consumption - Block 2 ( 20.38400 MJ/day)^ | 1,651.104 MJ | $0.0293700 per MJ | $48.49 |
| * Flexi Saver - Peak Consumption - Block 3 ( 48.53363 MJ/day)^ | 3,931.224 MJ | $0.0280500 per MJ | $110.28 |
| * Flexi Saver - Supply Charge | 81 days | $0.639100 per day | $51.77 |
| * NSW Government Gas Rebate | 81 days | $0.331507 per day | $26.85Cr |
| **Total Current Charges (incl. GST of $25.73)** | | | **$257.32** |

An * means that the amount shown includes GST.
^ This figure is your usage shown as an average per day over the number of days that apply to this rate.

**Next meter read**
Your next meter reading is planned to occur during 25 May - 4 Jun 2019.
Please ensure safe and clear access to the meter. If your meter is not accessible an estimate is taken.

**Gas usage**



Average daily use (Mj)
This account: **89.63**
Same time last year: **71.98**
Average cost per day (incl. GST): **$2.83**

**25% increase in usage since the same time last year**

- **Question**: Please enter your MIRN (Meter Installation Reference Number) from your most recent gas bill. If you are in New South Wales, this might be called a DPI (Delivery Point Identifier) rather than a MIRN. It will have the same structure in either case. Please take care doing this. It is very important for the study that this is accurate.
- **Response options**: Free entry, but with structural checks and numeric checksum

9. Age

- **Explanatory statement**: None
- **Question**: How old are you
- **Response options**:
  - Under 18
  - 18-24
  - 24-29
  - 30-34

- Etc
- 65-69
- 70-74
- 75+

- **Notes**: People who selected 'Under 18' were filtered out of the survey at this point

10. Gender

- **Explanatory statement**: None
- **Question**: Do you identify as?
- **Response options**:
  - Male
  - Female
  - Prefer to self-describe [Free text]
  - Prefer not to say

11. Dwelling type

- **Explanatory statement**: None
- **Question**: What type of dwelling is the residence you live in?
- **Response options**:
  - Separate house
  - Semi-detached townhouse, row house, terrace or villa
  - Apartment or unit
  - Caravan
  - Other (please provide details) [Free text]

12. Number of bedrooms

- **Explanatory statement**: None
- **Question**: How many bedrooms does the residence have? If it is a studio apartment or another type of dwelling without any separate bedrooms, please answer '0'
- **Response options**:
  - 0 bedrooms
  - 1 bedroom
  - 2 bedrooms

- Etc
- 7 bedrooms
- 8 or more bedrooms

13. Number of bathrooms

- **Explanatory statement**: None
- **Question**: How many full bathrooms does the residence have? Please do not include separate toilets or powder rooms without a shower or bathtub
- **Response options**:
  - 0 bathrooms
  - 1 bathroom
  - 2 bathrooms
  - Etc
  - 7 bathrooms
  - 8 or more bathooms

14. Solar PV panels

- **Explanatory statement:** None
- **Question**
  a. Does the residence have solar panels that generate electricity? Please don't include solar hot water
  b. What is the size of the solar installation? Please enter the size in kW, number of panels, or both – whatever you know
- Response options:
  a. Yes / No
  b.
  - Size in kW: [Free text]
  - Number of panels: [Free text]
  - Unsure (button)
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked part 'b'

15. Controlled load

- **Explanatory statement:**
  **What is controlled load?**

### How do I find out if I'm being billed for a controlled load?

Controlled load tariffs are called different things depending on where you live. Different retailers might also use different names too.

Here's a list of the common names in different states and territories:

| State/territory |
|---|
| Australian Capital Territory – Off-peak |
| New South Wales – Off-peak |
| Queensland – Tariff 31 or Tariff 33 |
| South Australia – Controlled load |
| Tasmania – Tariff 41 |

- **Question**
  a. Does the residence have a controlled load electricity connection? This is often referred to as off-peak electricity. This may be for hot water, pool heating or pumping, or underfloor heating.
  b. What household appliances / services are managed under the controlled load ("off-peak") connection?
- **Response options**:
  a. Yes / No / Unsure
  b. Please select all that apply
  - Hot water
  - Pool heating
  - Pool pump
  - Underfloor heating
  - Other [Free text]
  - Unsure which appliances/services
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked part 'b'

16. Electric vehicle

- **Explanatory statement:** None
- **Question**
  a. Does anyone who lives at the residence own an electric vehicle?
  b. How many electric vehicles are typically charged at the residence?
- **Response options**:

a. Yes / No

b. Free numeric entry

- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked part 'b'

17. Home battery system

- **Explanatory statement:** The energy storage capacity is the total amount of energy the battery can store. This is different to the amount it can produce at any point in time.
- **Question**

a. Does the residence have a battery energy storage system?

b. What is the energy storage capacity of the battery system (in kWh)?

- Response options:

a. Yes / No

b. Free numeric entry

- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked part 'b'

18. Hot water

- **Explanatory statement:** None
- **Question**

a. What is the primary energy source used in the residence for water heating?

b. Does the residence use any other energy sources for water heating? If not, please select 'Unknown / No other' in the second column.

- **Response options**:
  - Electric instantaneous
  - Electric storage
  - Electric heat pump
  - Electric (unsure of specific type)
  - Gas instantaneous
  - Gas storage
  - Gas (unsure of specific type)
  - Solar only
  - Solar electric boosted
  - Solar gas boosted
  - Solar (unsure of specific type)
  - Wood / solid fuel

- Other (please specify) [Free text]
- Unknown / No other

19. Hot water switching

- **Explanatory statement:** None
- **Question**
  a. In the last 18 months, have you switched the primary energy source used in the residence for water heating?
  b. When did you switch the primary energy source used in the residence for water heating?
  c. What was the primary energy source used in the residence for water heating before the switch?
- **Response options**:
  a. Yes / No
  b. Selection from drop down boxes for year and month
  c.
  - Electric instantaneous
  - Electric storage
  - Electric heat pump
  - Electric (unsure of specific type)
  - Gas instantaneous
  - Gas storage
  - Gas (unsure of specific type)
  - Solar only
  - Solar electric boosted
  - Solar gas boosted
  - Solar (unsure of specific type)
  - Wood / solid fuel
  - Other (please specify) [Free text]
  - Unknown / No other
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked parts 'b' and 'c'

20. Space heating

- **Explanatory statement:** None

- **Question**
  a. During cooler months of the year, what is the primary source of energy used in the residence for space heating?
  b. Does the residence use any other energy sources for space heating? If not, please select 'None of the above / No other' in the second column.
- **Response options**:
  - Electric central heating/ducted reverse cycle air conditioning
  - Gas central heating (e.g. ducted gas heating)
  - Reverse cycle air conditioner, not ducted (e.g. split-system or wall/window air conditioning used to heat and cool)
  - Individual electric room heater (e.g. radiant, convection, panel, oil-filled column or fan heater)
  - Individual gas room heater (e.g. flued or portable/unflued gas heater)
  - Electric underfloor heating
  - Hydronic underfloor heating
  - Other hydronic heating (e.g. radiant wall or ceiling panels)
  - Wood heater (e.g. fireplace)
  - Other (please specify): [Free text]
  - Don't know
  - None of the above / No other

21. Space heating switching

- **Explanatory statement:** None
- **Question**
  a. In the last 18 months, have you switched the primary energy source used in the residence for space heating?
  b. When did you switch the primary energy source used in the residence for water heating?
  c. What was the primary energy source used in the residence for space heating before the switch?
- **Response options**:
  a. Yes / No
  b. Selection from drop down boxes for year and month
  c.
  - Electric central heating/ducted reverse cycle air conditioning

  - Gas central heating (e.g. ducted gas heating)
  - Reverse cycle air conditioner, not ducted (e.g. split-system or wall/window air conditioning used to heat and cool)
  - Individual electric room heater (e.g. radiant, convection, panel, oil-filled column or fan heater)
  - Individual gas room heater (e.g. flued or portable/unflued gas heater)
  - Electric underfloor heating
  - Hydronic underfloor heating
  - Other hydronic heating (e.g. radiant wall or ceiling panels)
  - Wood heater (e.g. fireplace)
  - Other (please specify): [Free text]
  - Don't know
  - None of the above / No other
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked parts 'b' and 'c'

22. Space cooling

- **Explanatory statement:** None
- **Question:** During warmer months of the year, which types of air conditioning or space cooling does the residence typically use? Please select all that apply
- **Response options**:
  - Wall/window air conditioner
  - Split-system air conditioner
  - Ducted air conditioning
  - Fixed evaporative cooling
  - Portable evaporative cooling
  - Ceiling fan(s)
  - Pedestal fan(s)
  - Other type(s) of cooling
  - N/A – do not have any air conditioning or cooling

23. Cooking

- **Explanatory statement:** None
- **Question:** Which types of appliances are typically used in the residence for cooking? Please select all that apply

- **Response options**:
    - Electric induction cooktop
    - Electric ceramic cooktop
    - Electric cooktop with coil or solid hotplates
    - Gas cooktop
    - Wood-burning cooktop
    - Electric Oven
    - Gas Oven
    - Wood-burning oven
    - Microwave
    - Other (please specify) [Free text]
    - Unsure

24. Cooking switching

- **Explanatory statement:** None
- **Question:**
    - In the last 18 months, have you switched the energy sources you use for cooking?
    - When did you switch the energy sources you use for cooking?
    - Which types of appliances were typically used in the residence for cooking before the switch? Again, please select all that apply
- Response options:
    - Electric induction cooktop
    - Electric ceramic cooktop
    - Electric cooktop with coil or solid hotplates
    - Gas cooktop
    - Wood-burning cooktop
    - Electric Oven
    - Gas Oven
    - Wood-burning oven
    - Microwave
    - Other (please specify) [Free text]
    - Unsure
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked parts 'b' and 'c'

25. Large appliances

- **Explanatory statement:** None
- **Question:** What other large appliances are frequently used in the residence?
- **Response options**:
  - Clothes washing machine
  - Clothes drying machine
  - Dishwasher
  - Other (please specify) [Free text]
  - None

26. Swimming pool

- **Explanatory statement:** None
- **Question:**
  a. Does your residence have a swimming pool and/or outdoor spa? If you live in a block of units, apartments, townhouses, etc. do not count communal facilities that are shared by occupants in other residences.
  b. Does your swimming pool and/or spa have any of the following? Please select all that apply
- **Response options**:
  a.
  - Yes - a swimming pool
  - Yes - an outdoor spa/Jacuzzi
  - No

  b.
  - Electric heating
  - Gas heating
  - Solar heating
  - Pool cover
  - None of the above
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked part 'b'

27. Insulation

- **Explanatory statement:** None

- **Question:** In terms of insulation, does your residence have any of the following? Please select all that apply
- **Response options**:
  - Roof or ceiling insulation
  - Underfloor insulation
  - Wall insulation
  - Double glazed windows
  - No insulation
  - Don't know

28. Business

- **Explanatory statement:** None
- **Question:**
  a. Do you or any other members of your household run a business that operates from this residence?
  b. Does the business consume a large amount of energy relative to the amount that would be consumed at the residence if the business operated elsewhere? For example, operating power tools every day would typically consume a lot of energy. Doing accounts for a business would typically not.
- Response options:
  a. Yes / No
  b. Yes / No
- **Notes**: Only respondents that answered 'Yes' to part 'a' were asked part 'b'

29. People at home

- **Explanatory statement:** None
- **Question:** In a typical week in 2019, how many days would one or more people normally be in the residence during business hours of 9am to 5pm, Monday to Friday? For example due to working remotely, studying remotely, caring for somebody in the residence, or any other reason. Please answer this question as it relates to typical circumstances in 2019, NOT the current scenario with the coronavirus pandemic.
- **Response options:** Selection from 0-5

30. Household composition

- **Explanatory statement:** None

- **Question:** What best describes the composition of the residence?
- **Response options:** Selection from 0-5
  - 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 - single 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 (please specify) [ free text]

31. Home ownership

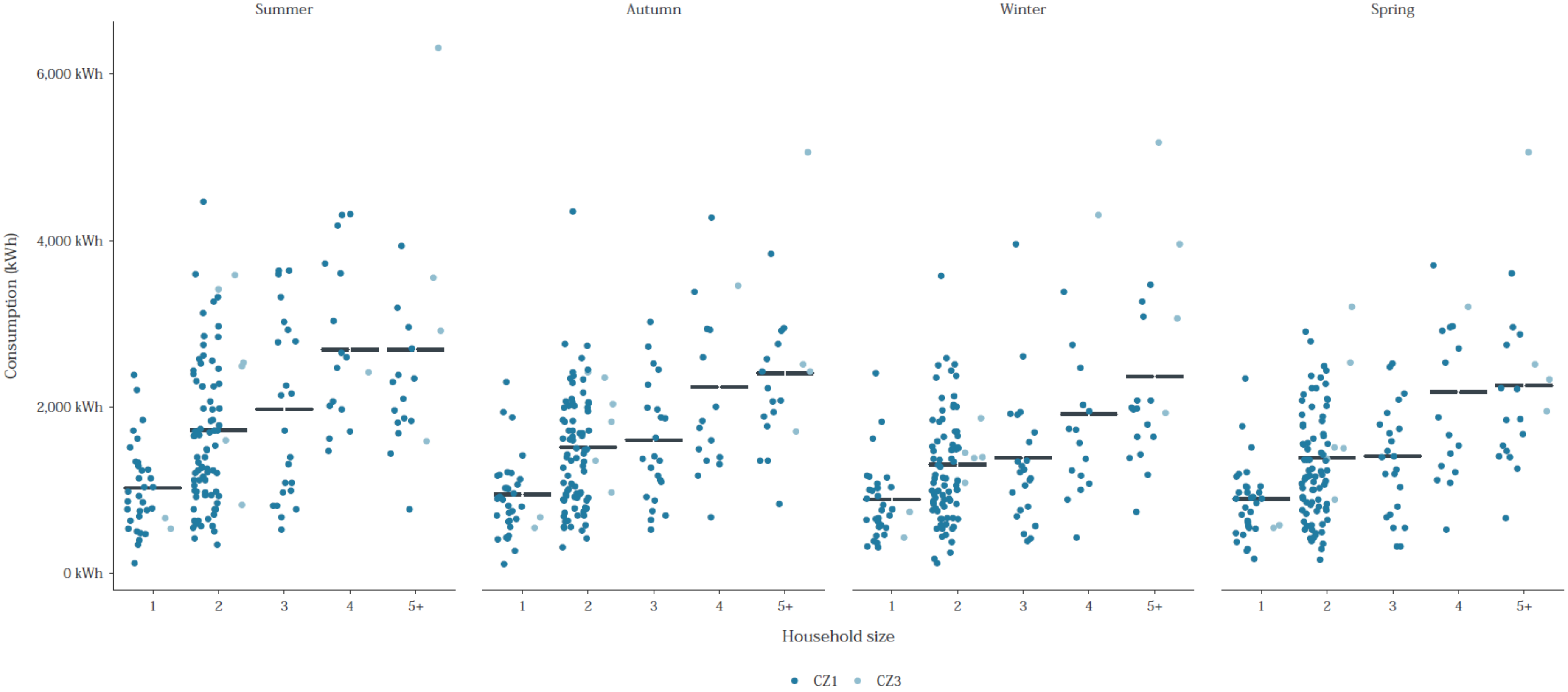
- **Explanatory statement:** None
- **Question:** In terms of home ownership, is the residence that you live in?
- **Response options:**
  - Owned outright or partially owned by someone in the residence
  - Rented by the occupants
  - Other (e.g. occupied rent free)

32.Vacancy

- **Explanatory statement:** None
- **Question:** How many weeks was the residence vacant during the following periods, for example, because you were on holidays during the period?
- **Response options:** Free numeric entry for each of the following
  a. Summer of 2018/19 (Dec, Jan, Feb)
  b. Autumn (Mar, Apr, May)
  c. Winter (Jun, Jul, Aug)
  d. Spring (Sep, Oct, Nov)

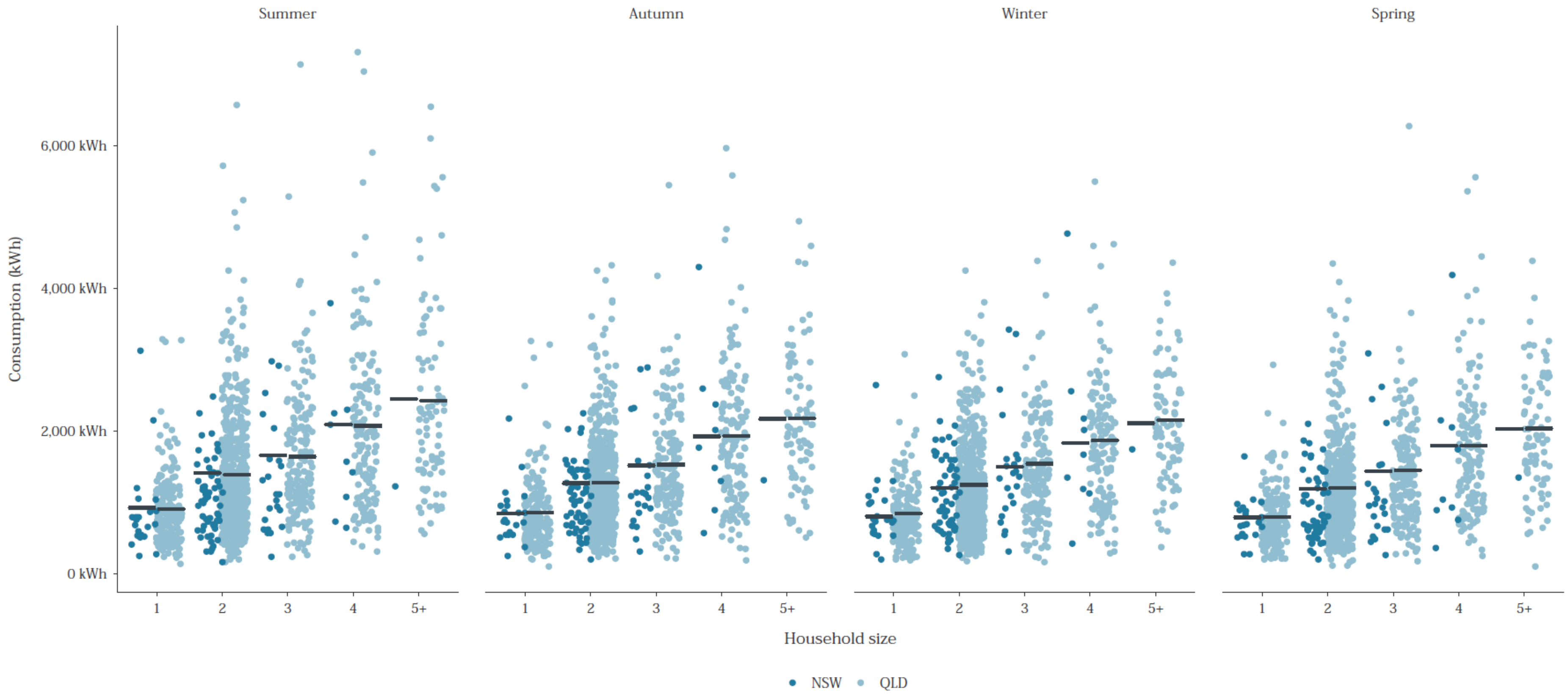
# E Seasonal electricity consumption and benchmarks

**Figure 24**: Climate Zones 1 and 3: seasonal consumption and benchmarks



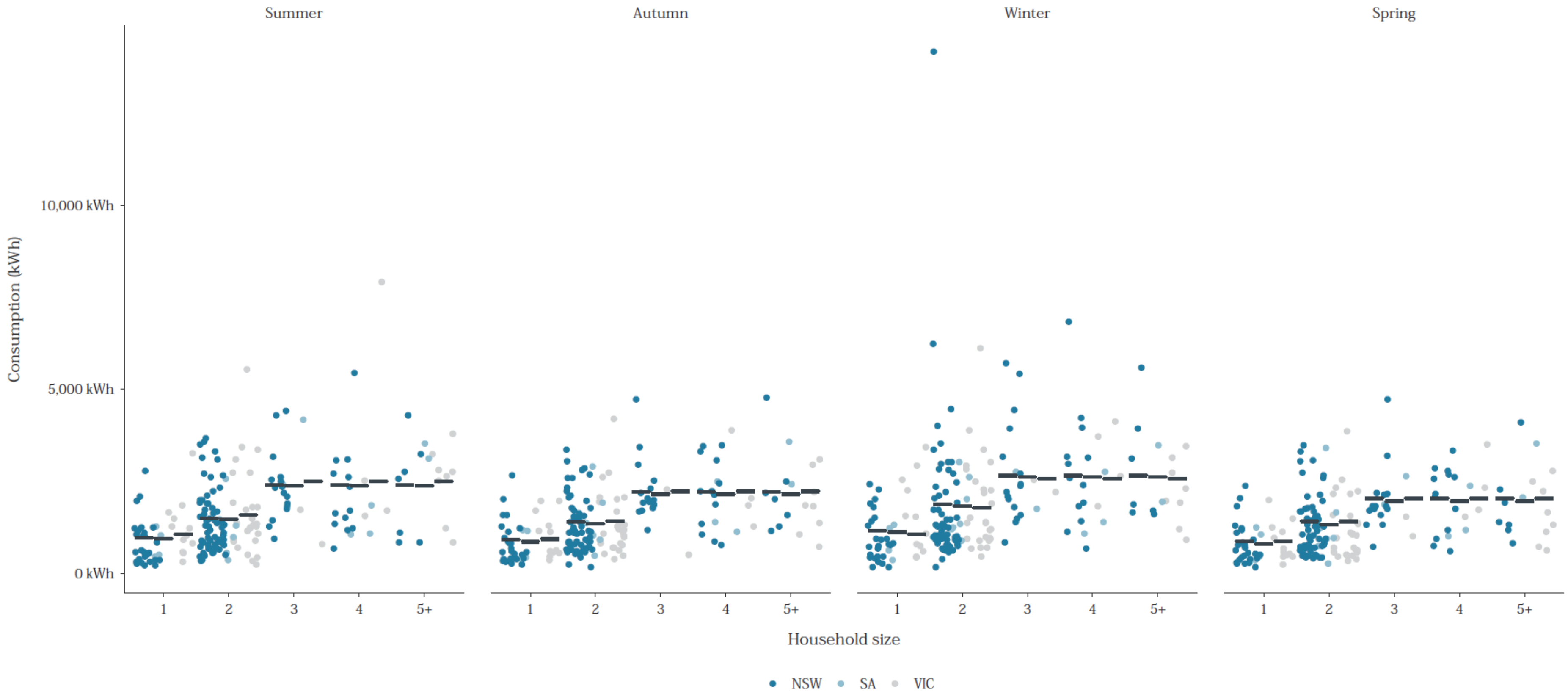

*Source: Frontier Economics*

**Figure 25**: Climate Zone 2: seasonal consumption and benchmarks



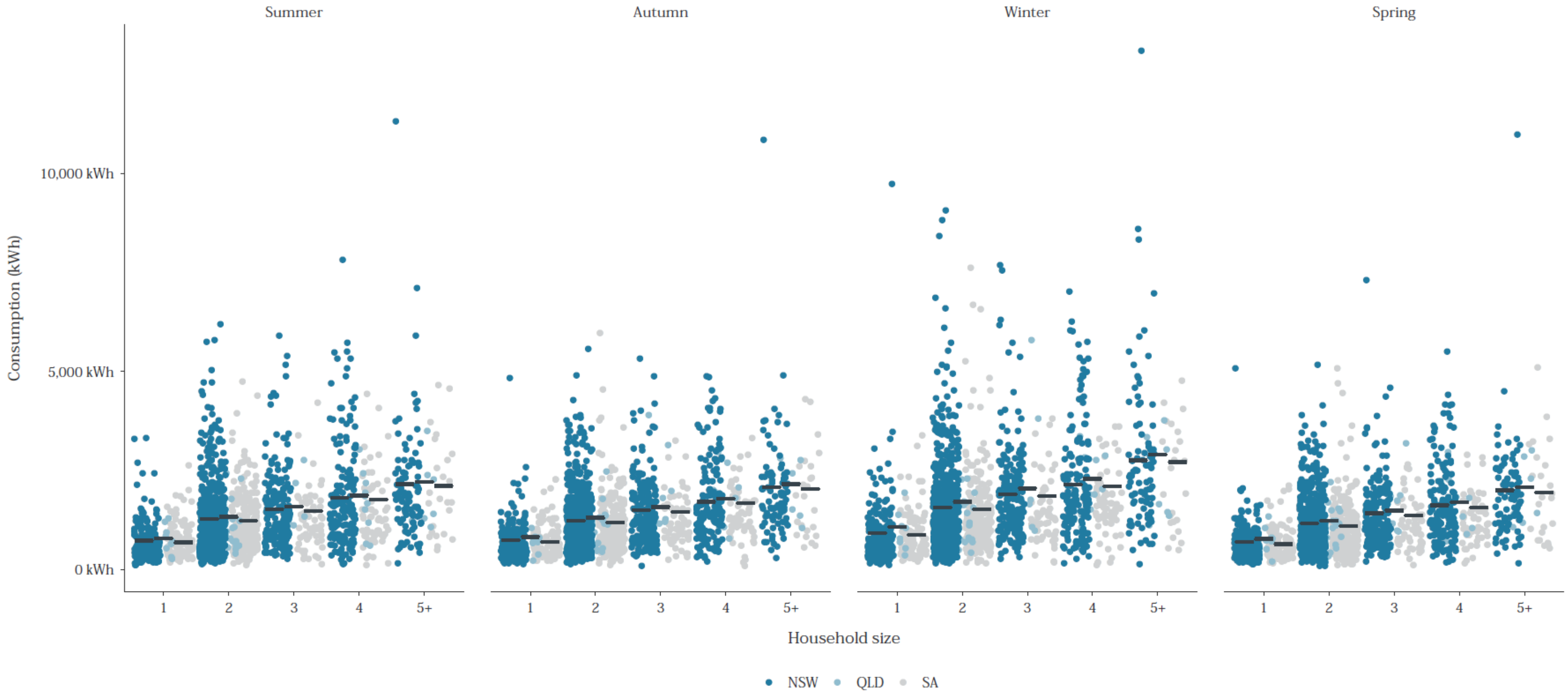

*Source: Frontier Economics*

**Figure 26**: Climate Zone 4: seasonal consumption and benchmarks



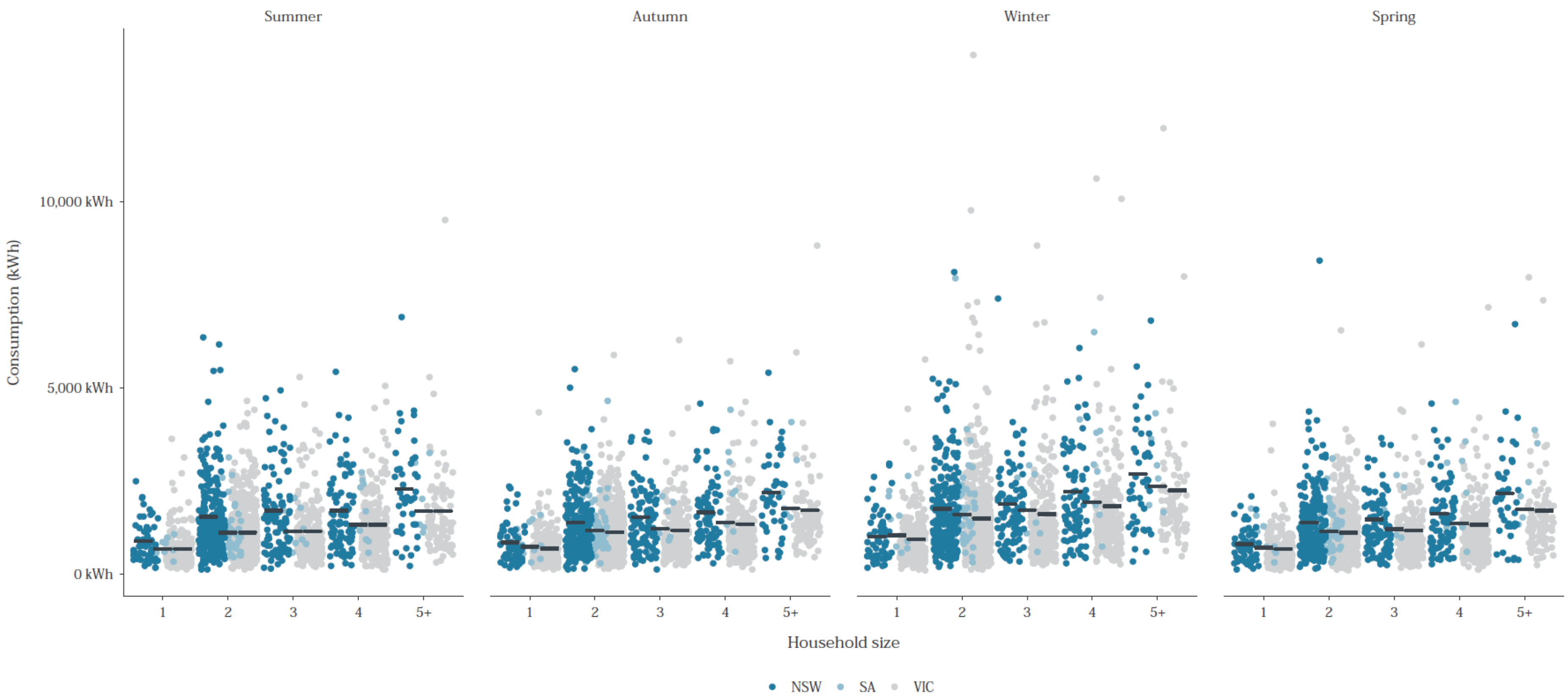

*Source: Frontier Economics*

**Figure 27**: Climate Zone 5: seasonal consumption and benchmarks



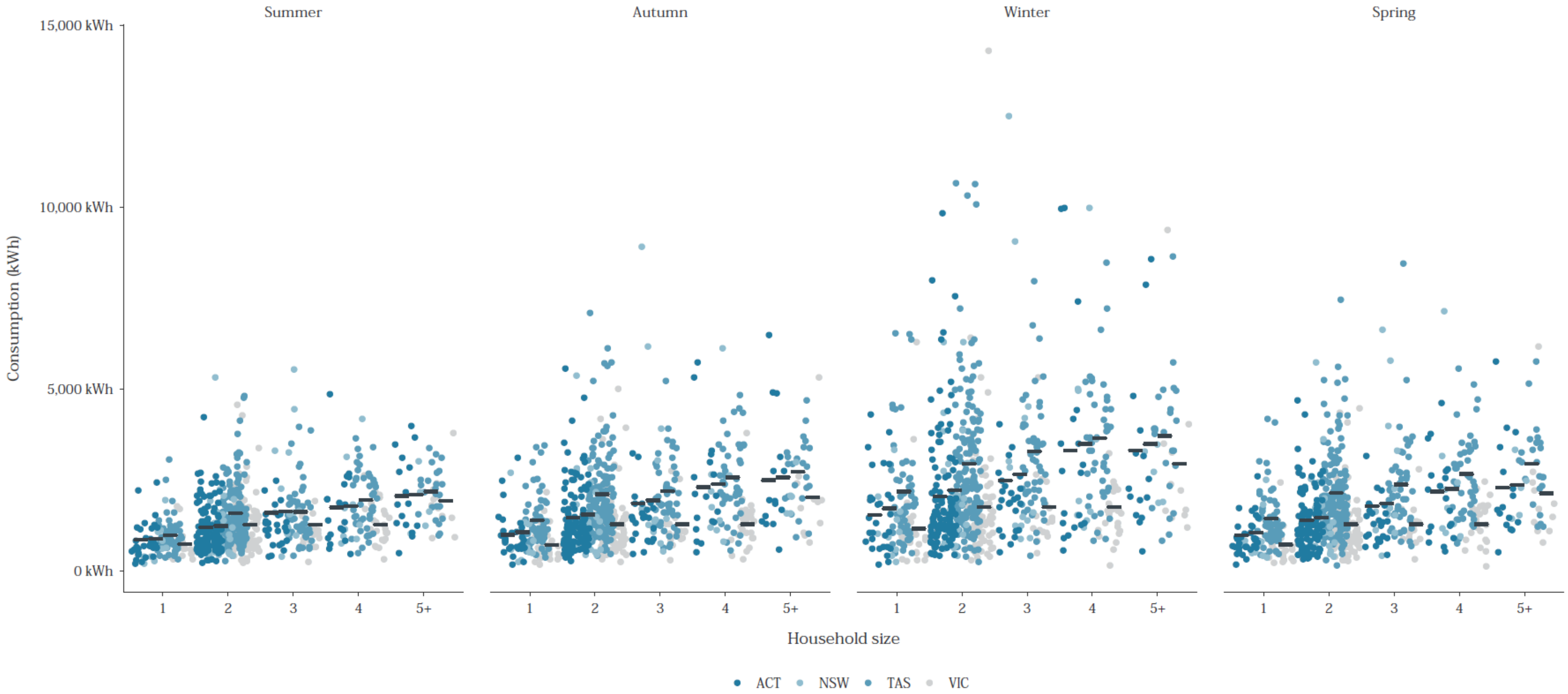

*Source: Frontier Economics*

**Figure 28**: Climate Zone 6: seasonal consumption and benchmarks




*Source: Frontier Economics*

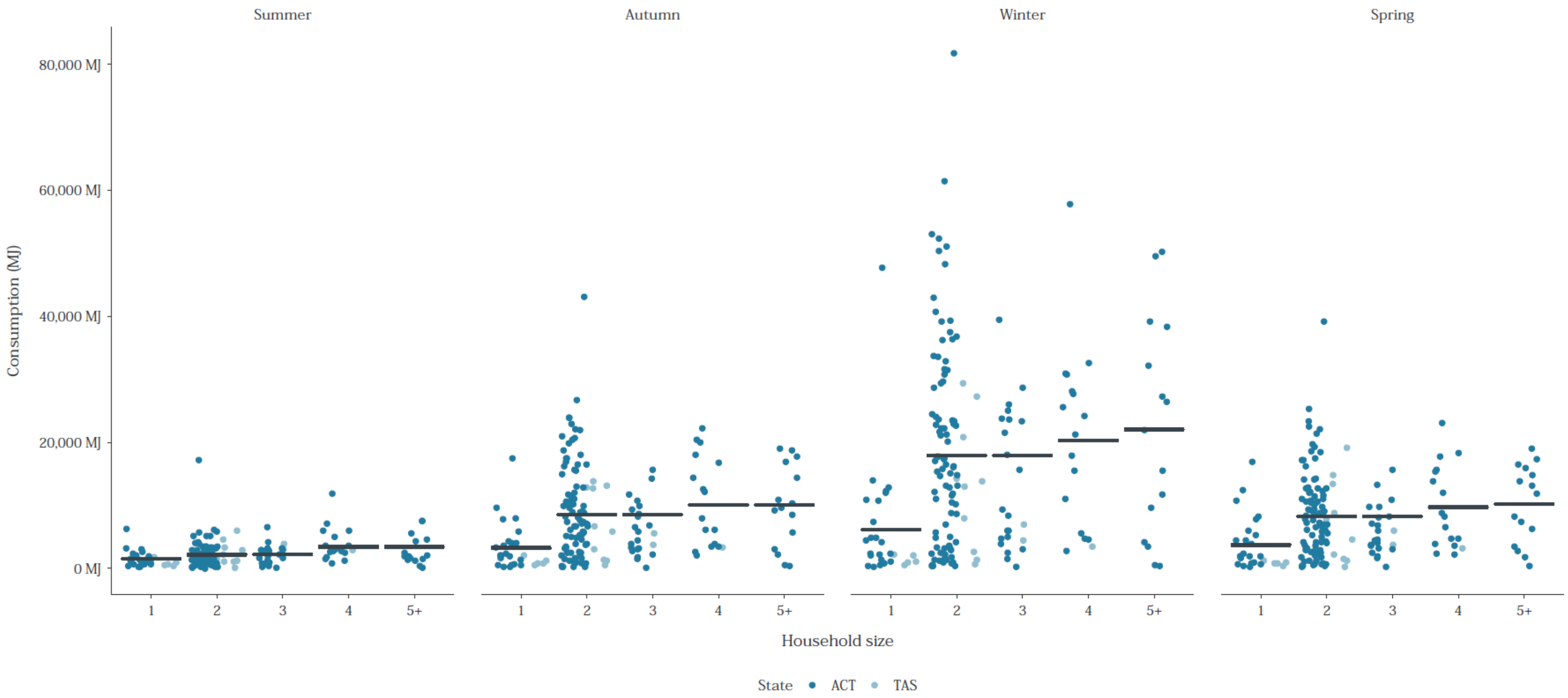
**Figure 29**: Climate Zone 7: seasonal consumption and benchmarks




*Source: Frontier Economics*

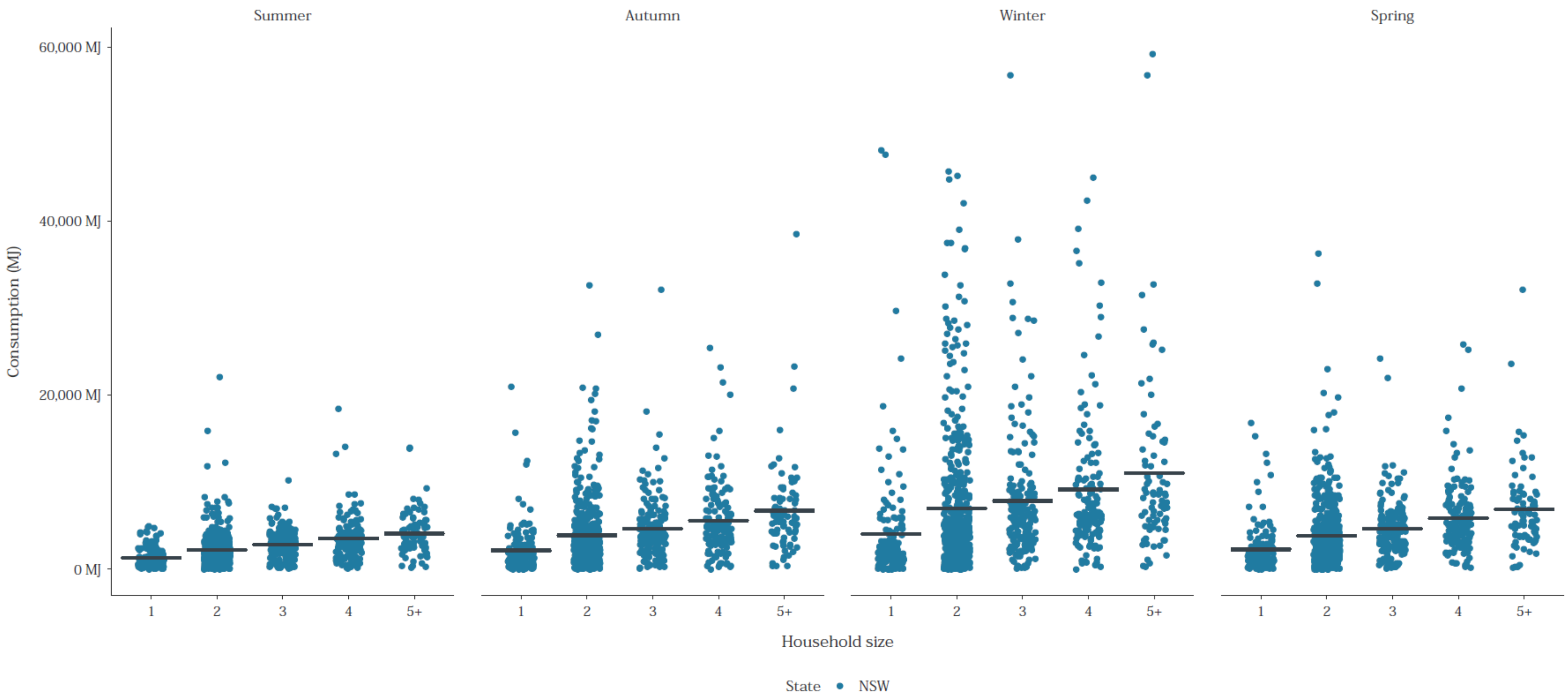
# F Seasonal gas consumption and benchmarks

**Figure 30**: ACT and Tasmania: seasonal gas consumption and benchmarks



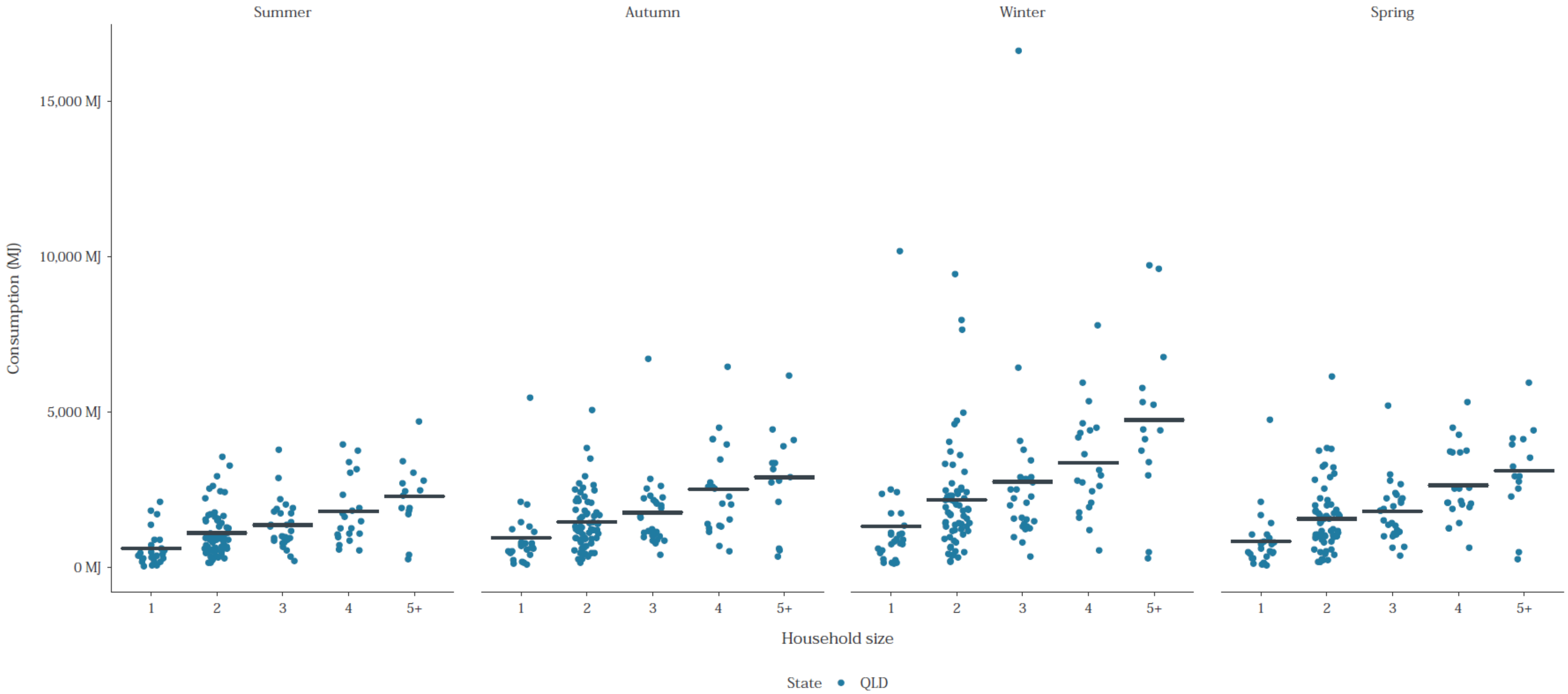

*Source: Frontier Economics*

**Figure 31**: New South Wales: seasonal gas consumption and benchmarks



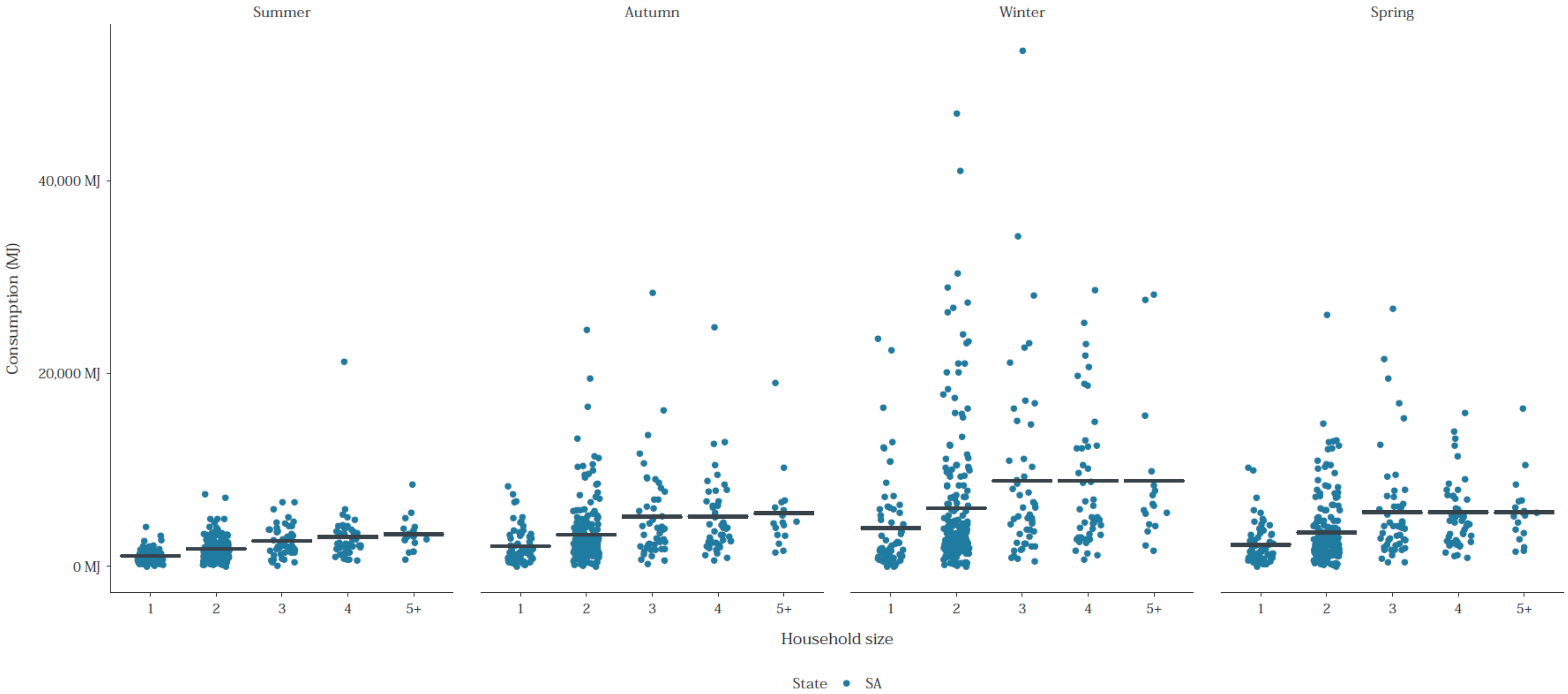

*Source: Frontier Economics*

**Figure 32**: Queensland: seasonal gas consumption and benchmarks



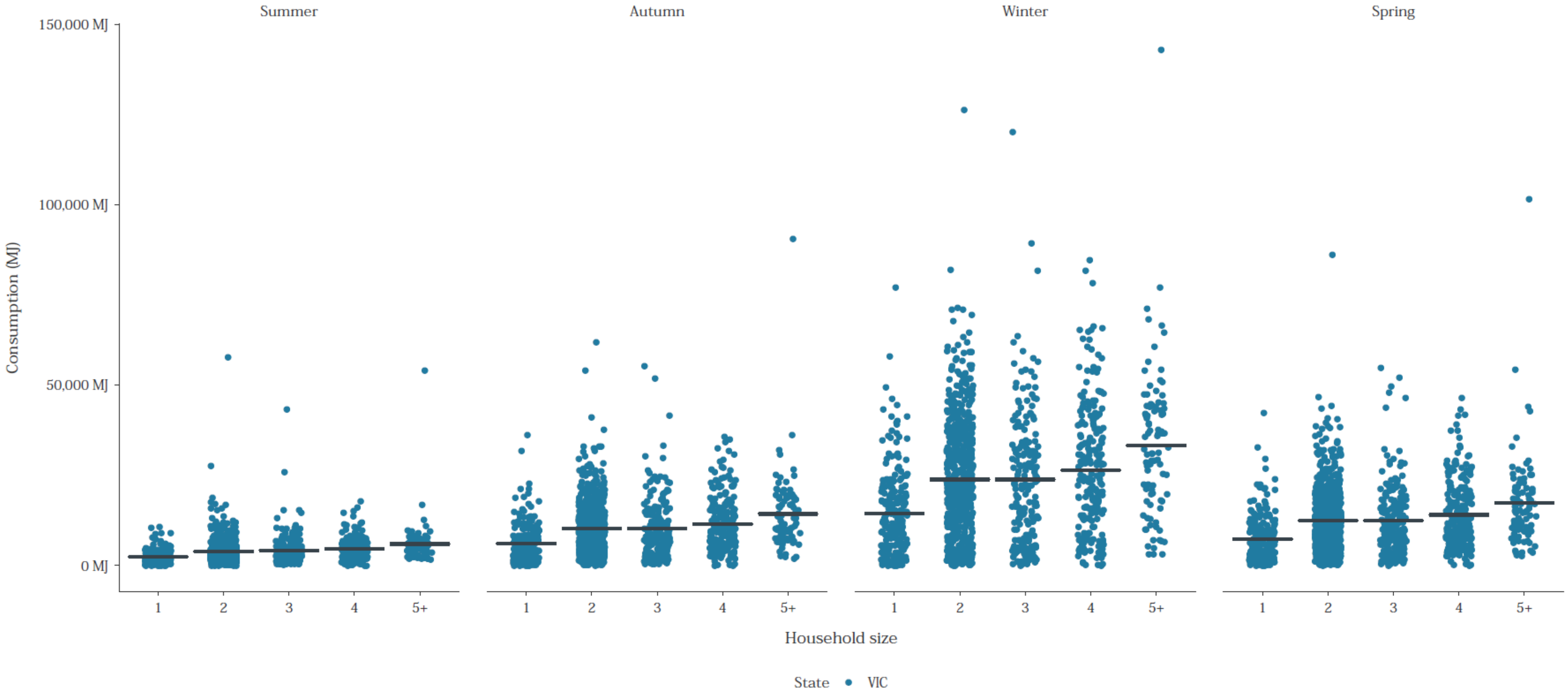

*Source: Frontier Economics*

**Figure 33**: South Australia: seasonal gas consumption and benchmarks




*Source: Frontier Economics*

**Figure 34**: Victoria: seasonal gas consumption and benchmarks




*Source: Frontier Economics*

**Frontier Economics**

Brisbane | Melbourne | Singapore | Sydney

Frontier Economics Pty Ltd
395 Collins Street Melbourne Victoria 3000

Tel: +61 (0)3 9620 4488
https://www.frontier-economics.com.au

ACN: 087 553 124 ABN: 13 087 553 124