# Demand response in the National Electricity Market

**FINAL REPORT**

**14 December 2020**

ENERGY SYNAPSE

ABN: 34 616 603 082

**Disclaimer**

This report has been prepared for the Australian Energy Market Commission (AEMC) as outlined in the Proposal and Engagement for Services. The services provided in connection with this engagement comprise an advisory engagement, which is not subject to Australian Auditing Standards or Australian Standards on Review or Assurance Engagements, and consequently no opinions or conclusions intended to convey assurance have been expressed.

Energy Synapse acts in a professional manner and exercises all reasonable skill and care in the provision of its professional services. This report has been commissioned by and prepared for the exclusive use of the AEMC. It is subject to and issued in accordance with the agreement between the AEMC and Energy Synapse. Energy Synapse is not responsible for any liability and accepts no responsibility whatsoever arising from the misapplication or misinterpretation by third parties of the contents of this report.

Except where expressly stated, Energy Synapse does not attempt to verify the accuracy, validity or comprehensiveness of any information supplied to Energy Synapse for its reports. We have indicated within this report the sources of the information provided. We are under no obligation in any circumstance to update this report, in either oral or written form, for events occurring after the report has been issued in final form.

The findings in this report have been formed on the above basis.

All queries related to the content, or to any use of this report should be addressed to Marija Petkovic and emailed via info@energysynapse.com.au

# 1 Executive Summary

Energy Synapse has been engaged by the AEMC to help characterise the availability and key features of demand response in the National Electricity Market (NEM) across residential, commercial, and industrial sectors.

As part of this engagement, Energy Synapse has undertaken the following:

(a) Assessment of the potential demand flexibility in the NEM by analysing the data submitted by Registered Participants in 2020 in AEMO's Demand Side Participation Information (DSPI) portal.

(b) Stakeholder consultation process with electricity retailers and aggregators to gain a first-hand account of how demand response is being implemented in the NEM.

(c) Analysis of historical pricing and generator bidding data to qualitatively assess the potential of demand response to impact market price outcomes.

Our key findings are summarised below.

(a) AEMO's 2020 Electricity Statement of Opportunities estimates there is approximately 4.3 GW of potential demand flexibility in the NEM. Based on our survey of sample retailers and aggregators, at least 412 MW has been activated in the NEM over the past three years. Several of the survey participants declined to answer how much demand response they have activated, and hence the true number is likely to be higher.

(b) Retailers and aggregators were found to be utilising a large variety of demand side resources ranging from industrial process interruptions, embedded generation, air conditioning, hot water, battery storage, pool pumps, electric vehicles and more. Market reform efforts would benefit from taking a broad view of demand flexibility in order to better harness the full potential of demand side participation.

(c) Retailers and aggregators strongly believed in offering customers choice over what resources are controlled and the ability to manually override an intended response if needed. The voluntary nature of how demand response works in practice is important to emphasise as there can be a misconception that demand response is something that is 'forced' on energy users. Some aggregators also had internal strategies, such as oversubscribing demand response programs, to help manage the risk of under delivery during a demand response event, while still providing their customers with adequate flexibility.

(d) The biggest barriers to demand response across all sectors related to building a bankable investment case. The financial payment not being attractive enough combined with low revenue certainty, technology costs, and a low understanding of demand response made the investment decision more challenging for energy users. Some aggregators suggested that a rebate for installing hardware/control equipment would make the investment decision easier to understand by customers. Other respondents indicated that capacity style payments could help firm up investment cases by overcoming the uncertainty of payments in the spot market.

Ahead notice/markets were not seen as something that would materially help the business case.

(e) The biggest factor driving preferences for notice periods was whether the response was automated or manual. Automated demand response generally required notice periods less than five minutes, whereas manual processes tend to prefer at least one hour. Respondents across all sectors showed little interest in day ahead or multi-day notice periods and did not feel that this would enable them to utilise their response more effectively.

(f) Retailers and aggregators were generally strongly in favour of greater automation stating that it would reduce risks to market participants, enable shorter notice periods to be used and ultimately result in higher cost savings for energy users. While several of the respondents in our survey had high levels of automation in their portfolios (some as high as ≥85%), others had quite low levels of automation, particularly those facilitating behavioural demand response and those who had customers with highly manual industrial processes. Greater automation could not only unlock more volume of demand response, but could also potentially make it easier for demand response to integrate/participate directly in the wholesale market.

(g) The majority of survey respondents across residential, commercial and industrial sectors indicated that they could maintain a full response for at least two hours. This is well suited to historical pricing patterns. Our analysis of historical price spikes over the last three financial years shows that spot prices ≥ $5000/MWh have tended to cluster in durations of two hours or less in a given day. Less frequently, these high price events have lasted for longer periods such as 4.5 or 5.5 hours. A response duration of two hours would have been sufficient to cover 70% of hours where the spot price was ≥ $5,000/MWh.

(h) The NEM features steep generator bid stacks. Analysis of generator bidding behaviour shows that when prices spike, particularly above $5,000/MWh, very little volume tends to be offered at bid bands between $500 and $10,000/MWh. Analysis of both the DSPI data and the results of our survey indicate a willingness to trigger demand response in the $300-1,500/MWh range. This suggests that demand response could provide valuable competition to the market in times of scarcity. This has potential to put downward pressure on prices for all consumers, if the market were to clear at a lower price as a result of demand response bids.

(i) When it comes to views on market reform, common concerns were raised by stakeholders about requiring loads to be scheduled in the same way as generators and that this would lock out a significant portion of energy users. Concerns were also raised about developing baselines, which were seen as especially challenging for the residential sector and could even act as a disincentive for those who provide a regular response.

# Table of Contents

# 2 Introduction

Energy users have been providing demand response since the commencement of the National Electricity Market (NEM). However, the characteristics of this demand response have been notoriously opaque. This is because demand response has traditionally been implemented via confidential bilateral contracts between energy users and electricity retailers and network providers, rather than an open market mechanism.

As part of the Post-2025 market design program, the Energy Security Board, AEMC, and AEMO are investigating potential design options for a two-sided market that could allow demand response to be harnessed more efficiently as we continue the energy transition.

Throughout this report, we use the term "demand response" quite broadly to refer to all forms of demand flexibility. This includes controllable embedded generation and storage, in additional to load curtailment. This approach allows interested parties to better understand the full spectrum of demand flexibility and how it could be used to support the future grid.

## 2.1 Definitions of demand response characteristics

Energy Synapse has used the following definitions when characterising the key features of demand response in the NEM (see explanatory diagram in Figure 1 for further clarification).

**Notice period** is the time from receiving a notification that demand response is required to physically starting the response.

**Response time** is the time it takes to physically complete the load reduction (or injection).

**Response duration** is a measure of how long the full response could be maintained.

**Physical availability** is a measure of how often the response could be activated, assuming that appropriate financial incentives are in place.

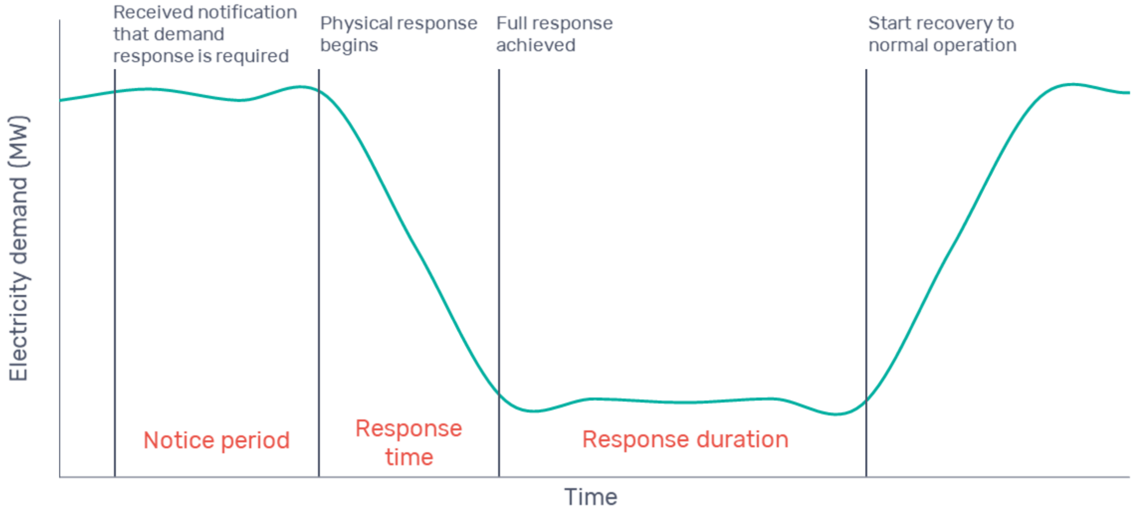



Figure 1: Explanation of key terms used to characterise different forms of demand response.

# 3 Demand flexibility potential in the NEM

AEMO has developed a data portal that requires registered NEM participants to submit their Demand Side Participation (DSP) information in accordance with National Electricity Rules Clause 3.7D and the DSP Information Guidelines [1]. The data from this portal is used by AEMO for forecasting purposes.

The DSP Information Portal gives participants the opportunity to submit information such as the maximum potential size of the response, the load type (i.e. residential, commercial or industrial), the technology type of the response, trigger prices, which party controls the response, and more. The full list of fields is explained in the DSP Information Guidelines [1]. The Guidelines describe whether submissions within each field are 'compulsory' or 'optional'.

Energy Synapse has reviewed a selection of data in the DSP Information Portal, submitted by Registered Participants as at April 2020. The data was provided by AEMO in a format to enable Energy Synapse to explore and draw insights referred to in sections 3.1 – 3.4 of this report. It is sourced from the same data set that was utilised in AEMO's 2020 Electricity Statement of Opportunities (ESOO). The ESOO [2] provides further detail around the granularity, potential applications and limitations of DSP Information Portal data.

The field of most interest in this study was the 'POTENTIAL_RESPONSE' field. As per AEMO's Guidelines, this field is a measure of "maximum MW of potential response" for each entry [1]. Hence, this field gives an indication of the theoretical flexibility that exists. It does not provide information about how much demand response has been physically activated.

Energy Synapse has analysed the potential response across several variables, including sector, type/technology, and who controls the response, subject to data limitations[1].

## 3.1 Demand flexibility by type (technology)

Based on the data provided, there is approximately 4.3 GW of potential demand flexibility in the NEM.

We examined the 'DSP_Type' field to determine how this demand flexibility was being achieved.

As shown in Figure 2, the largest portion (49%) was attributed to 'load reduction', closely followed by 'embedded generation' at 46%.

Much of the specified embedded generation in the DSP Information Portal is solar PV, some of which could switch off in response to negative prices. However, our surveys and case studies found that backup generators (which can switch on at high prices) are a common form of response in the commercial and to a lesser extent industrial sector.

[1] Participants have obligations under the NER to report their demand response capability. However, AEMO has limited means to verify the provided information. In the past, AEMO has identified reporting inaccuracies and has worked with participants to correct these. Furthermore, because most of the data fields are voluntary, the portal provides an incomplete picture of the NEM.

While demand response has traditionally been associated with load reductions, the high potential that exists in various forms of embedded generation, suggests that market reform efforts would benefit from taking a broader view of demand flexibility in order to better harness the full potential of demand side resources.

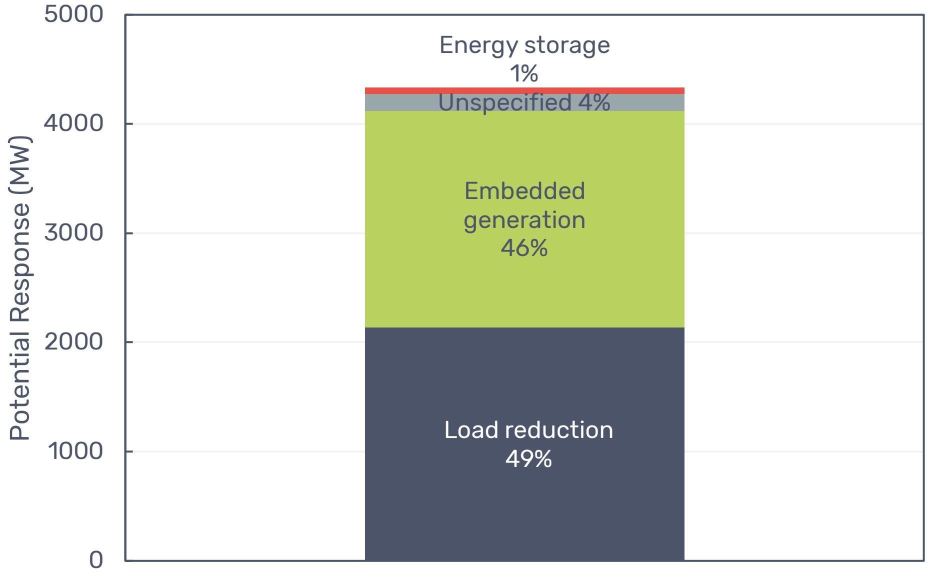



Figure 2: Potential response by DSP type. Data from AEMO 2020 DSPI portal.

## 3.2 Demand flexibility by sector

Energy Synapse examined the 'LOAD_TYPE' field to determine how the potential response was segregated across different sectors.

Energy Synapse manually examined the 'NAME' field (the only compulsory field in the database). In instances where the 'NAME' field allowed us to easily identify an organisation as belonging to the industrial or commercial sector, we manually categorised the record as such. This allowed the unspecified response to be reduced by 300 MW. The full results of our analysis are shown in Figure 3.

Based on the specified data, the residential sector appears to have significantly more potential flexibility than the commercial and industrial sectors.

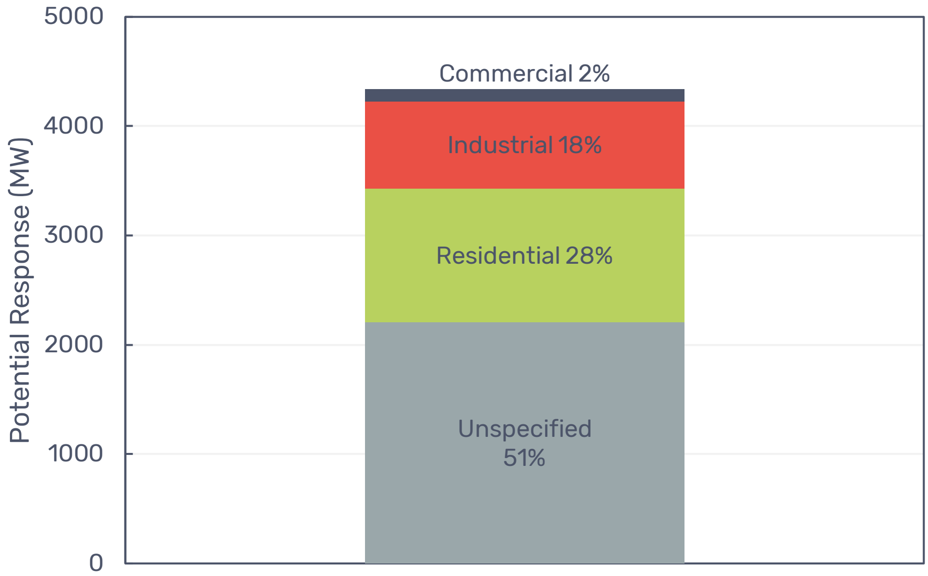



Figure 3: Potential response in the NEM by sector. Data from AEMO's 2020 DSPI portal.

## 3.3 Who controls the response

Energy Synapse examined the 'RESPONSE_CONTROL' field to determine which parties controlled the potential response.

The full results are shown in Figure 4.

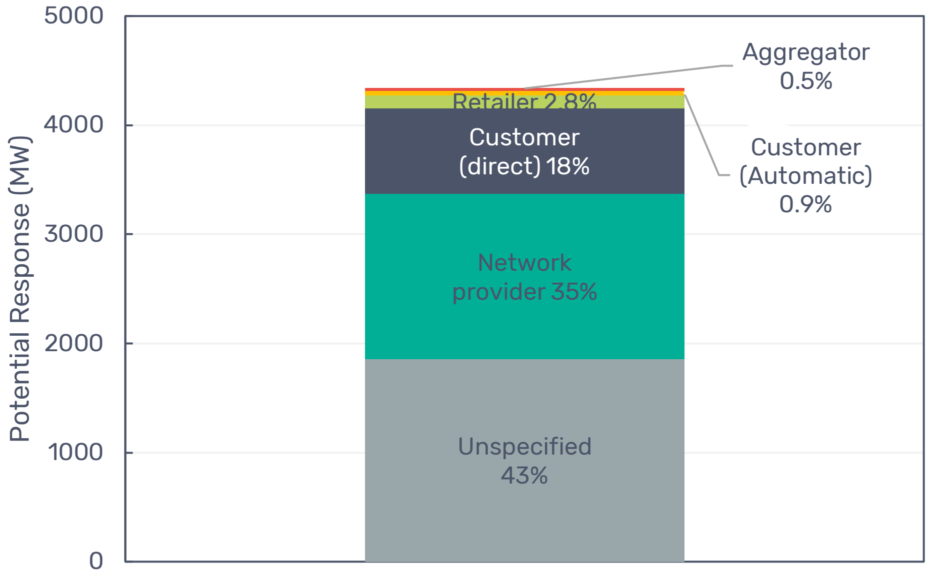



Figure 4: Who controls the potential response. Data from AEMO 2020 DSPI portal.

Out of the specified data, network providers controlled the highest potential response (1.5 GW). All 1.5 GW were recorded as being a load reduction. 1.2 GW were recorded as being in the residential sector with the remaining 300 MW unspecified. Given these characteristics, it is likely that the network provider's response is dominated by residential hot water systems under controlled load tariffs.

Customer (direct) was the next highest potential response (785 MW). In the DSP Information Portal, "customer (direct)" refers to a response that is activated manually by the energy users. In contrast, "customer (automatic)" refers to a response that is activated by a free running algorithm, such as a timer operated hot water storage system [1]. Out of the 785 MW customer (direct) potential response, 593 MW were specified as being in the industrial sector. Industrial energy users utilise a wide variety of processes and control systems, which can have varying degrees of automation. Furthermore, industrial energy users often face more complex safety and business risk considerations when implementing demand response compared with other energy users. In this context, it is not surprising to see industrial energy users directly controlling their response.

## 3.4 Trigger Prices

AEMO's 2020 Electricity Statement of Opportunities examined how flexible loads, as reported to AEMO (including those with embedded generators), have responded to various price levels in the past three years [2]. This cumulative price curve data is summarised in Table 1.

Based on the survey results as well as our own experience in helping to facilitate demand response, the 239 MW of response represented in Table 1 is likely to be a small portion of the total price driven response that has been activated in the NEM.

Table 1: Price responsiveness of demand response. Data from AEMO's 2020 Electricity Statement of Opportunities [2].

| Trigger Price | AEMO price driven DSP forecast (cumulative response in MW) |
|---|---|
| >$300/MWh | 78 |
| >$500/MWh | 152 |
| >$1,000/MWh | 171 |
| >$2,500/MWh | 216 |
| >$5,000/MWh | 230 |
| >$7,500/MWh | 239 |

# 4 Questionnaire results

Energy Synapse created an online questionnaire to shed light on the key characteristics of demand response that is currently active in the NEM. Although network providers control a large portion of the demand flexibility in the NEM (as shown in Chapter 3), the questionnaire was focused on electricity retailers and aggregators. This is because this report is primarily focused on understanding how demand flexibility may be able to be harnessed in the wholesale energy market. Hence, the market experience of retailers and aggregators offered the most relevant learnings.

The questionnaire asked a series of multiple-choice questions and also provided opportunities for participants to clarify their responses and provide further comments. Energy Synapse also directly followed up where appropriate to further clarify responses. The questionnaire template can be found in the Appendix.

Energy Synapse received responses from 11 retailers and aggregators. Energy Synapse also received a response from an industry association representing industrial energy users, who was asked to provide further perspective and context on the experience of its members. Due to the commercially sensitive nature of the questionnaire, individual responses will not be identified in this report.

The questionnaire was split into three different sections for the residential, commercial and industrial sectors, in order to understand how the characteristics of demand response varied across sectors. Responses have been aggregated across these sectors, with permission from the participants.

The key high-level findings are summarised in the dot points below. The following sections detail the results in full.

(a) Over the past three years, at least 19 MW of residential, 128 MW of commercial, and 265 MW of industrial demand response have been activated in the NEM.

(b) Specialist aggregators were able to control ≥85% of the household load in their portfolios. Although their portfolios were relatively small in volume, this very high level of control shows promising potential for what could be possible in the residential sector.

(c) The biggest factor driving preference for notice periods was whether the response was automated or manual. Automated demand response generally required notice periods less than five minutes. Manual processes preferred at least an hour notice. Another contributing factor for the industrial sector specifically, was the need for production planning. As a result, 71% of industrial demand response portfolios needed at least one-hour notice. When exploring the issue of notice periods, we also tried to assess whether respondents would benefit from the extra certainty that could come with ahead markets. Somewhat surprisingly, respondents across all sectors indicated relatively little interest in day or multi-day notice periods, with many not thinking this would materially enhance their ability to respond to wholesale energy prices.

(d) Residential demand response had the fastest response time, with 83% of respondents indicating they could respond within five minutes. In contrast, the most common response for commercial demand response was 15-30 minutes (answered by 50% of respondents). This was predominately due to the time required to start backup generators. In the industrial sector, response times varied significantly with 26% of portfolios being able to respond within five minutes, while 23% needed 1-2 hours. This reflects the high level of variation in the industrial sector when it comes to type of plant/equipment and level of automation.

(e) The majority of respondents in residential, commercial, and industrial sectors indicated that they could maintain a full response for at least two hours. As per our findings in Chapter 6, this suggests that demand response could be very well suited to most high pricing events that occurred in the energy market.

(f) There was a wide range of responses provided when respondents were asked to consider how often their portfolios would be physically available. Answers within sectors ranged from daily to as low as a few times a year. This largely reflects the differences in the types of load/generation being used to provide demand response as well as whether the response was automated or manual (with behavioural demand response in particular experiencing more "response fatigue"). Residential and commercial portfolios were also more susceptible to seasonal and time of day/week variations in availability.

(g) The biggest barrier to demand response in every sector was the "financial payment not being attractive enough". Other financial metrics such as "technology costs" also tended to rank highly. This suggests that building a bankable investment case is a key obstacle to implementing demand response.

(h) Another recurring theme was the challenge of getting energy users interested in demand response. This suggests that further adoption of demand response will require greater consumer education. This barrier also reflects the views of some energy users (particularly those from the industrial sector), who prefer not to be interruptible because energy trading is not their core business. While ahead markets would provide more certainty from a production scheduling perspective, it may not make a material difference for those energy users who simply prefer to keep their process online so they can keep producing the product which earns revenue for their business.

## 4.1 Residential demand response

Of the 11 retailers and aggregators who were surveyed, eight indicated that they had active residential demand response portfolios.

Please note that the percentages in all the charts in this section are weighted by respondent. Our preferred approach would be to weight the responses by the megawatt volume of the respondent's portfolio. However, as some respondents were reluctant to provide portfolio sizes due to confidentiality concerns, each respondent was effectively given equal weighting. As a result, extra care needs to be taken when interpreting the results. Note that "N" refers to the number of respondents that provided a response to each question.

### 4.1.1 Size of portfolio and types of resources under control

Five out of eight respondents with residential demand response portfolios provided a value for the maximum amount of demand response that they activated at any one time in the past three years. The total aggregated value of the responses was 19 MW.

This is a very small fraction of the 1.2 GW of potential residential response that was identified in AEMO's DSP Information Portal. This could be due to a large portion of residential load flexibility, such as hot water, being controlled by network providers via controlled load tariffs rather than retailers and aggregators. Furthermore, the data received from AEMO's DSP Information Portal only provides a "potential response", rather than how much response has been activated in the market.

Residential demand response providers appeared to have a high interest in utilising as much of the household load as possible. 75% of respondents indicated that they utilise more than one type of load in their residential demand response portfolios. Figure 5 shows that battery storage was the most common technology to be used for residential demand response (utilised by 75% of respondents). However, there was a high uptake of other technologies as well, with air conditioning, hot water, pool pumps, and electric vehicles being utilised by at least 50% of respondents.

The "other" category included various general appliances as per customer agreements.

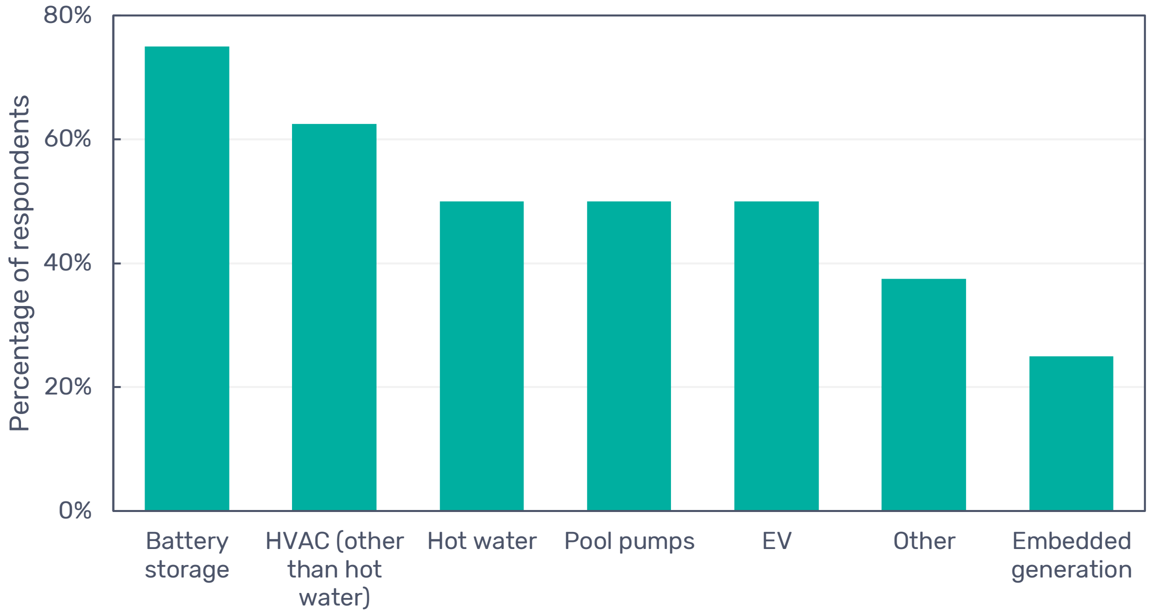



Figure 5: Loads/equipment that are being used in residential demand response. N = 8.

Unsurprisingly, specialist aggregators generally indicated that they were able to harness a very high portion of the flexibility that exists in their residential portfolios (≥85%). In contrast, large retailers, who naturally have much larger book sizes, tended to indicate that their current residential demand response portfolios likely represented less than 15% of the total flexibility that potentially exists in their residential load portfolios. This suggests that there could be a large, relatively untapped opportunity to harness more demand side resources in the residential sector.

Our results found a strong divide in how residential demand response is implemented when it comes to automation. Half of the respondents indicated that their portfolios were highly automated, having direct control over at least 75% of their residential demand response portfolio (see Figure 6). In contrast, the other half of respondents were more focused on behavioural demand response (i.e. consumers taking their own actions). These respondents were in direct control of only 3-20% of their residential demand response portfolios.

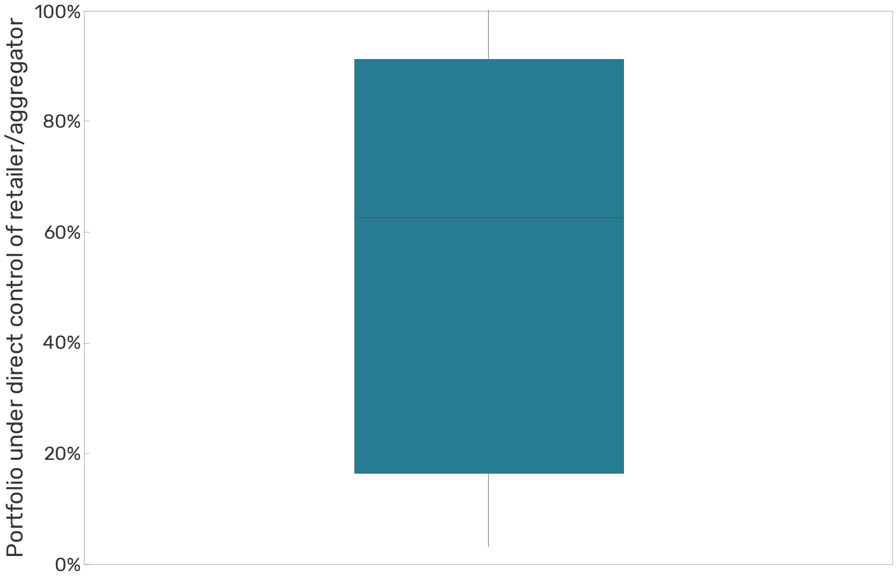



Figure 6: Percentage of residential demand response portfolio under direct control of the retailer or aggregator. N = 8.

### 4.1.2 Response characteristics

***Notice period***

Figure 7 shows the notice period that would allow respondents to utilise their residential demand response portfolios most effectively.

The data shows a divide between automated and behavioural demand response. Where retailers/aggregators had a high level of automation/direct control, they preferred shorter notice periods (immediate or within five minutes).

For behavioural demand response, longer notice periods of several hours and up to a day were generally preferred. Note however that some respondents engaging in behavioural demand response indicated that they could implement a response almost immediately. This could be due to the specific processes that are used to engage with customers.

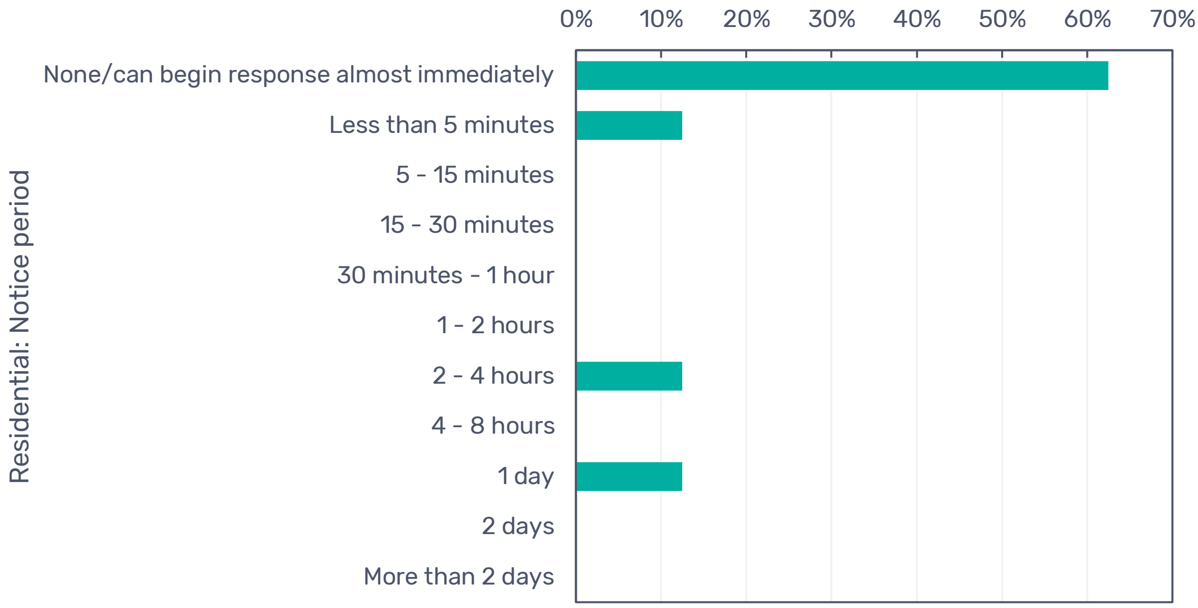



Figure 7: Average notice period for residential demand response portfolio for each respondent. N=8.

### *Response time*

In terms of the time required to physically enact a response, residential demand response was relatively fast responding. 54% of retailers/aggregators indicated they could respond within one minute. 83% indicated they could respond within five minutes.

Some respondents also noted that the response time of air conditioners can vary across different brands.

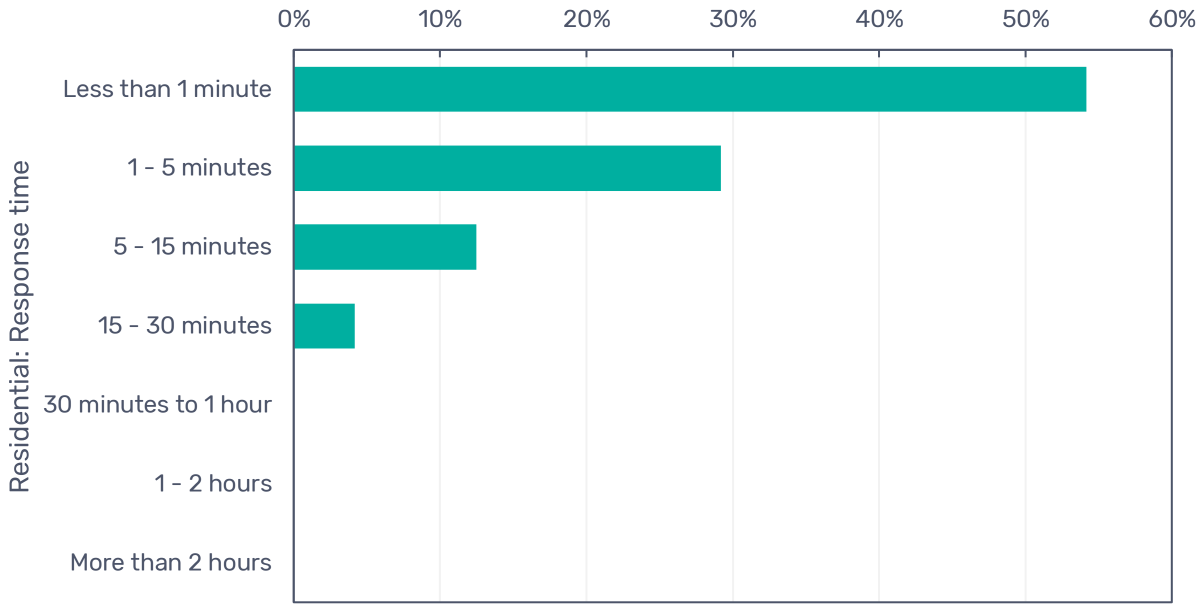



Figure 8: Average response time for residential demand response portfolio for each respondent. N=8.

### *Response duration*

The most common response from respondents was that they would be able to maintain a full response for an average of 2 – 4 hours (38%). A further 38% indicated that they could maintain a response for more than four hours. Based on our analysis of historical spot prices in the NEM in Chapter 6, residential demand response would be well placed to be able to respond to most high price events.

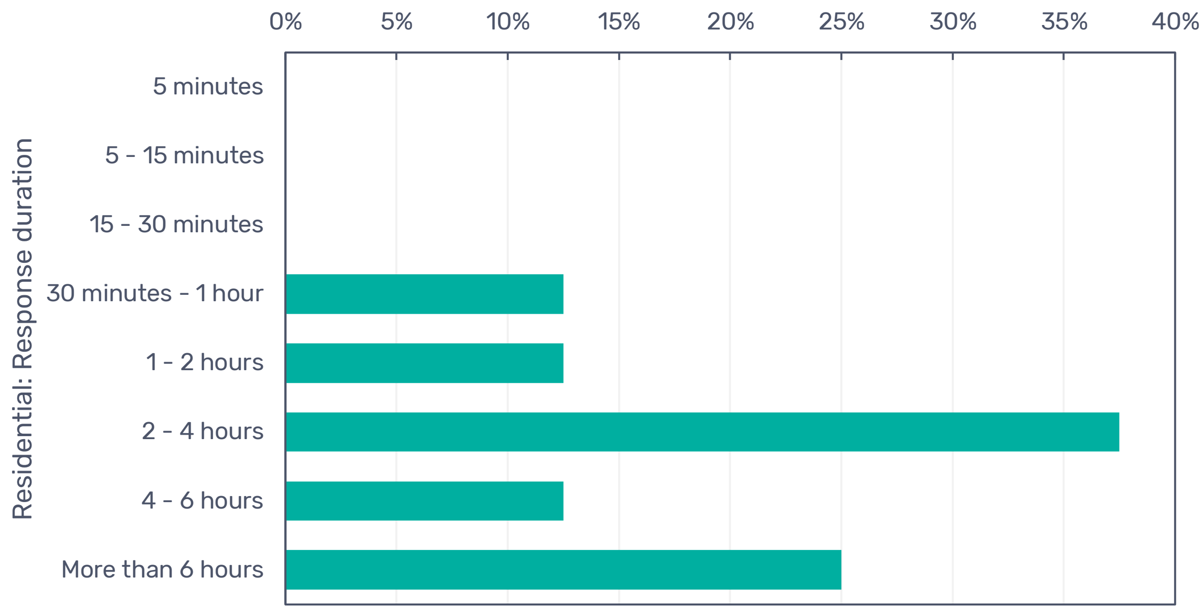



Figure 9: Average response duration for residential demand response portfolio. N = 8.

### *Physical availability*

When it came to expected physical availability, there was once again a divide between automated and behavioural demand response. Those favouring automated processes indicated they could respond at least once a day.

For behavioural demand response, participants generally thought the program would be difficult to sustain if a frequent response was required, and hence preferred less frequent events (a few times a month or even a few times a year).

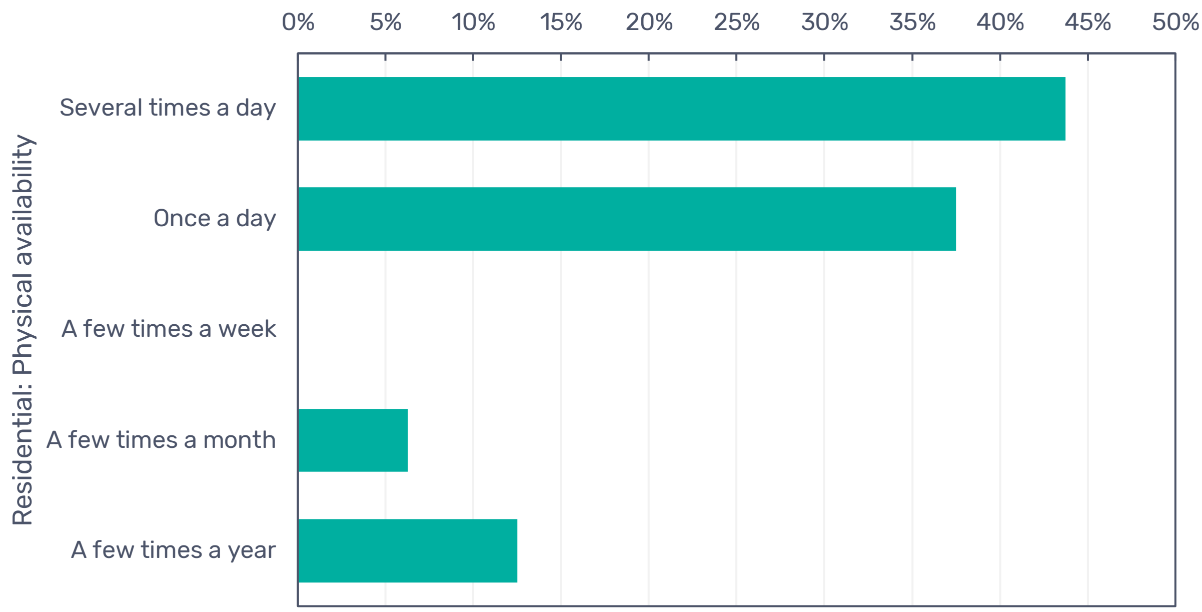



Figure 10: Expected physical availability for residential demand response. N = 8.

Many respondents also indicated that the demand response they were able to provide would likely be impacted by seasonal factors. For example, ambient temperature affects the available load for demand response that utilises hot water systems and air conditioning.

### 4.1.3 Barriers to residential demand response

Figure 11 shows how the respondents ranked the biggest barriers they face in implementing residential demand response. The biggest barrier was the financial payment not being attractive enough followed by engaging with customers.

The third barrier was aggregators not being able to provide residential demand response directly to the wholesale energy market. This will be an ongoing barrier for the residential sector, as it is excluded from the wholesale demand response mechanism coming into effect in 2021.

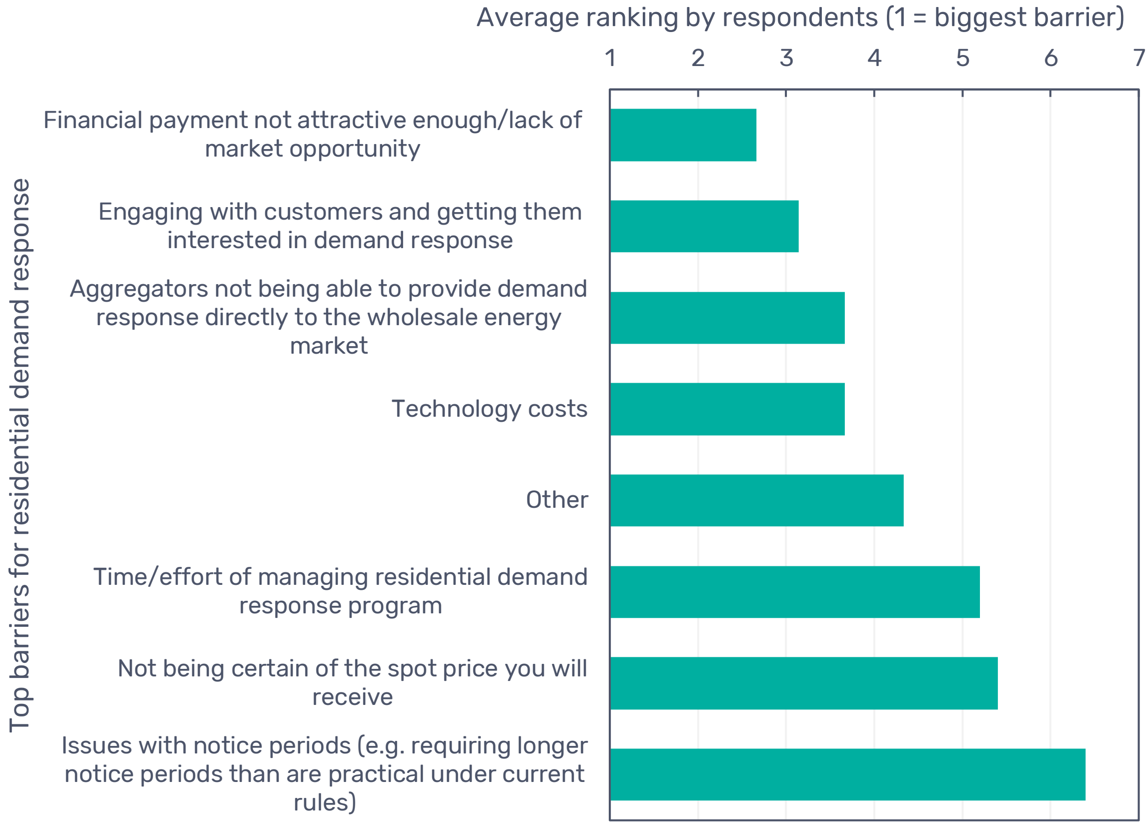



Figure 11: Barriers to residential demand response. Respondents were asked to rank eight barriers. The results for each barrier were then averaged. A lower average indicates that the issue was perceived as a bigger barrier. N = 7.

Some of the barriers mentioned in the “other category” included:

- A lack of consistency in technology standards for new technology, such as control systems for EV chargers, making aggregation difficult; and

- Negotiating agreements with wholesale suppliers.

#### 4.1.4 Trigger prices

Respondents indicated a range of trigger prices for when they would consider offering demand response ("negawatts" ) in the wholesale energy market. These generally ranged from $300/MWh to $1,000/MWh. These relatively low trigger prices, combined with the high physical availability shown by many respondents, suggests that residential demand response has the potential to be active quite regularly in the market.

## 4.2 Commercial Demand Response

Out of the 11 retailers and aggregators who were surveyed, six indicated that they had an active commercial demand response portfolio.

Please note that the percentages in all the charts in this section as weighted by respondent. Our preferred approach would be to weight the responses by the megawatt volume in the respondent's portfolio. However, as some respondents were reluctant to provide portfolio sizes due to confidentiality concerns, each respondent was effectively given equal weighting. As a result, extra care needs to be taken when interpreting the results. Note that "N" refers to the number of respondents that provided a response to each question.

### 4.2.1 Size of portfolio and types of resources under control

Three out of six respondents were willing to provide a value for the maximum amount of demand response they have activated in the NEM at any one time in the past three years. The total aggregate value was 128 MW.

Embedded generation was by far the most common technology being utilised in commercial demand response (used by over 80% of respondents). HVAC (other than hot water) was the second most common technology and was used by 33% of respondents. 50% of respondents indicated they were utilising more than one type of load/technology in their commercial portfolio.

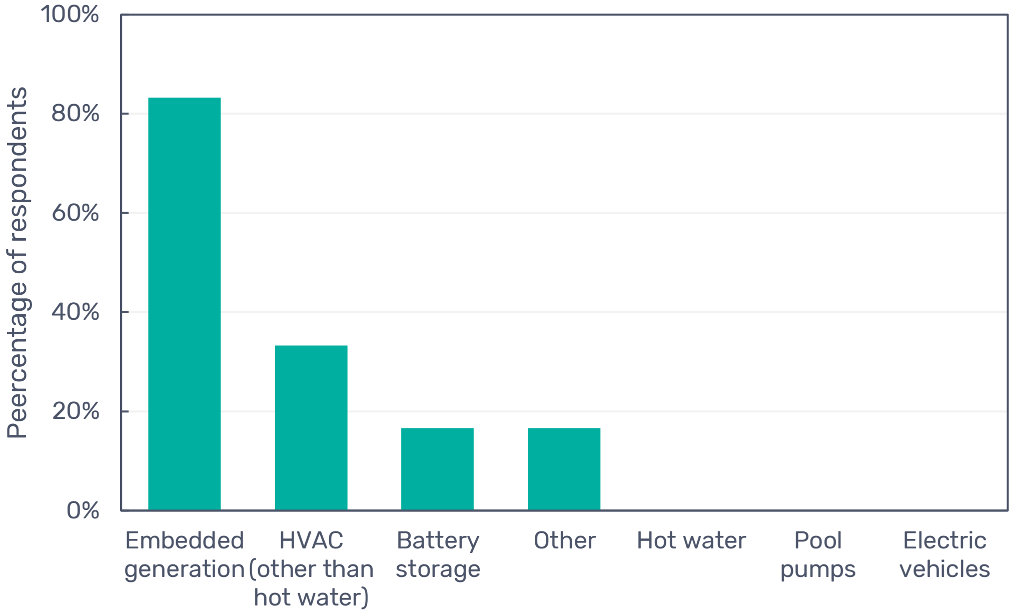



Figure 12: Technology being utilised in commercial demand response. N = 6.

Similar to residential demand response, approximately half of retailers/aggregators were using a highly automated approach to commercial demand response where 70% of the portfolio was under direct control. In contrast, other respondents utilised a manual response on the customer's side. For these respondents, the portfolio under direct control was only 2-20%.

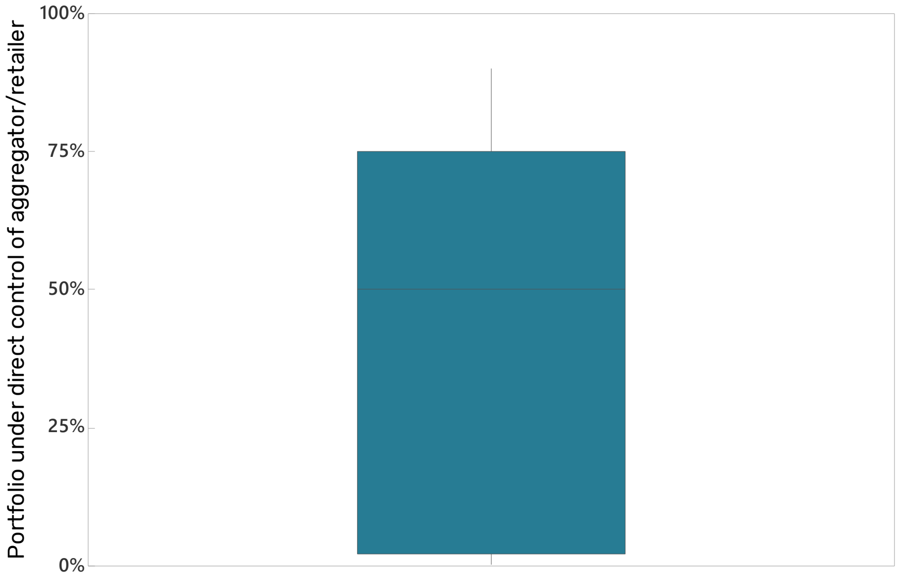



Figure 13: Percentage of commercial demand response portfolio under direct control of the retailer or aggregator (as opposed to behavioural demand response). N = 6.

### 4.2.2 Response characteristics

***Notice period***

On average, commercial demand response programs preferred a longer notice period than residential demand response, with 50% preferring one hour or more.

However, respondents did not feel that they needed one or two days notice.

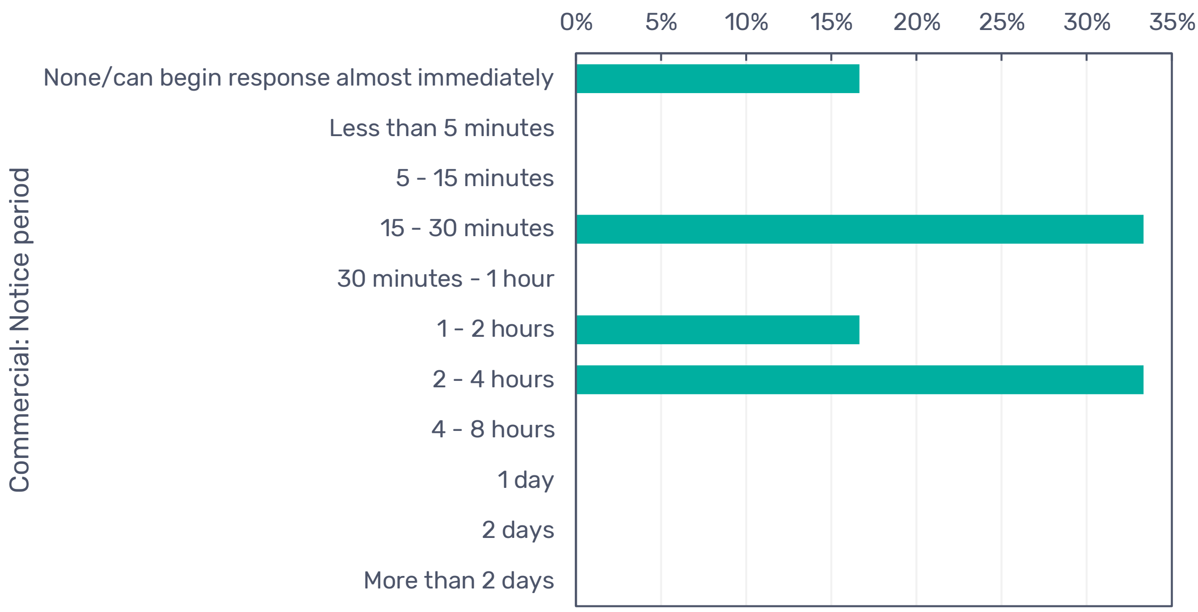



Figure 14: Average notice period for commercial demand response. N = 6.

### *Response time*

Physical response times varied from 1 to 30 minutes. 50% of respondents indicated that their physical response time is 15-30 minutes. The commercial sector frequently utilises backup generators to provide demand response. These respondents indicated that starting up backup generators was the key reason for the 15-30 minute response time.

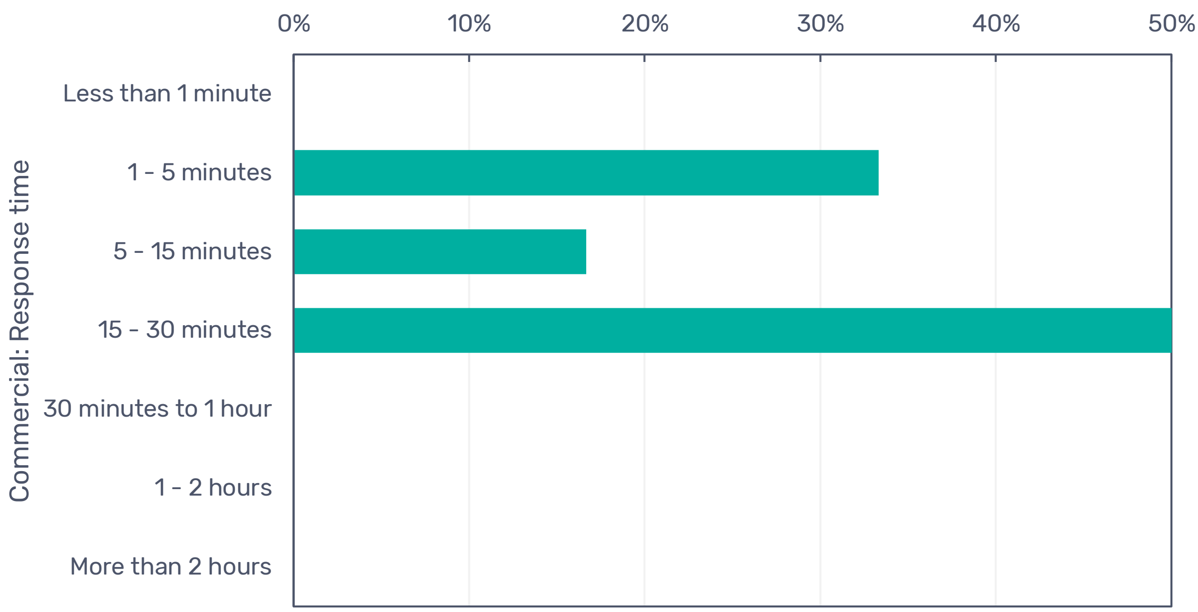



Figure 15: Average response time for commercial demand response. N = 6.

### *Response duration*

All respondents indicated that they could maintain the full response for at least one hour, with two thirds indicating they could maintain the response for at least two hours. This would be suitable for most high pricing events as explored in Chapter 6.

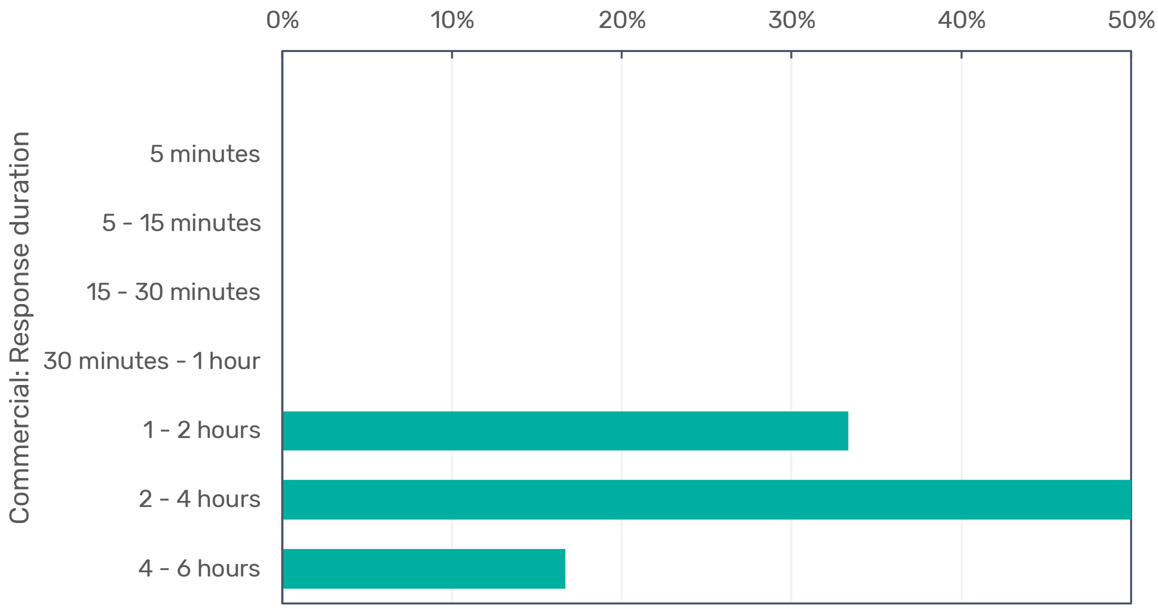



Figure 16: Average response duration for commercial demand response. N = 6.

### *Physical availability*

50% of respondents indicated that their commercial demand response portfolios would be physically available to respond on a daily basis. This was the most common response. Others indicated less frequent availability such as a few times a week or a few times a month.

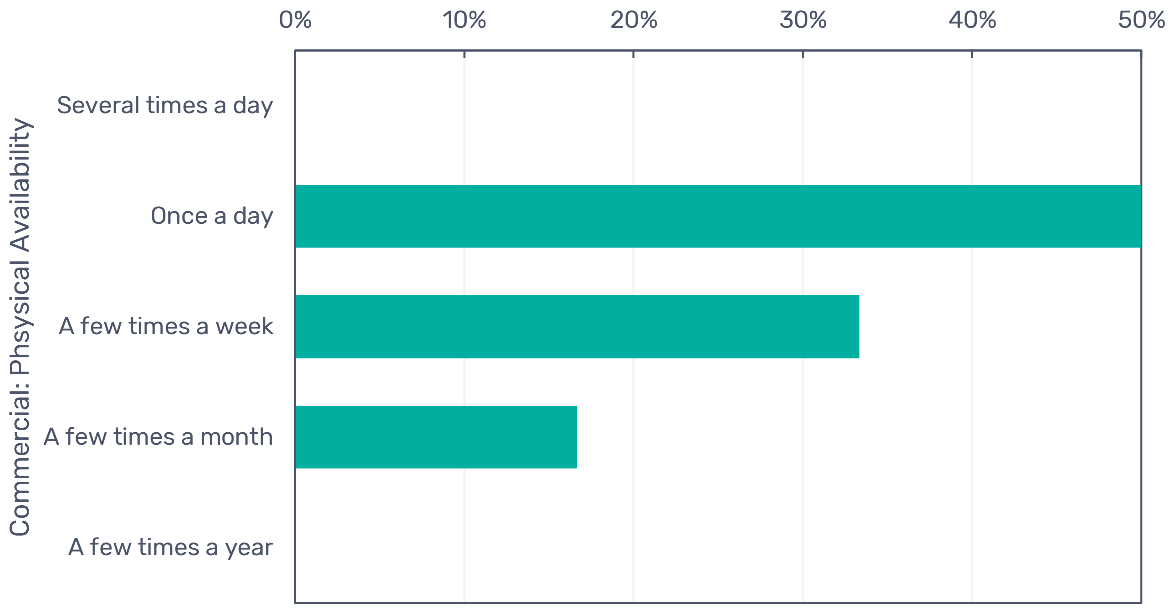



Figure 17: Commercial physical availability. N = 6.

Some respondents indicated that there would be strong time of day/seasonal variations. For example, as many commercial sites operates 9am-5pm on weekdays, there would naturally be less load to curtail on weekends/public holidays or after 5pm.

Some commercial portfolios also had temperature sensitivities, as there could be less load physically available for curtailment when ambient temperatures and cooling loads are lower.

### 4.2.3 Barriers to commercial demand response

The financial payment not being attractive enough was ranked as the biggest barrier to commercial demand response. The average ranking for this barrier (1.7) was significantly lower than other barriers. This indicates that this was a standout concern for respondents. The second biggest barrier was technology costs. Together, this suggests that building an investment case is a key challenge in implementing commercial demand response.

Engaging with customers and getting them interested in demand response was the third biggest barrier. This suggests a role for greater (as well as on-going) education of energy users to increase awareness of what demand response is and how energy users can benefit.


Figure 18: Barriers to commercial demand response. Respondents were asked to rank eight barriers. The results for each barrier were then averaged. A lower average indicates that the issue was perceived as a bigger barrier. N = 6.

### 4.2.4 Trigger prices

Trigger prices for commercial demand response tended to be more varied compared with the residential sector. Commercial trigger prices ranged from >$300/MWh to as high as >$5,000/MWh.

## 4.3 Industrial Demand Response

### 4.3.1 Size of portfolio and types of resources under control

Five electricity retailers/aggregators and an industry association responded to parts of the industrial survey. They represented energy users from a wide variety of sectors, including:

- Aluminium smelting
- Building products
- Chemicals
- Food and beverage
- Industrial equipment
- Mining
- Pulp and paper
- Steel production
- Textiles

Three retailers/aggregators were willing to provide a value for how much industrial demand response they activated at any one time in the last three years. The aggregated value was 265 MW. Victoria represented the highest load reduction out of any state (48% of aggregate response).

All six respondents indicated that they achieve a response by ramping up/down or interrupting industrial processes. Half of the respondents indicated that they also utilise embedded generation in addition to interrupting processes.

Three out of four aggregators/retailers indicated that they were in direct control of at least 50% of their industrial demand response portfolio (see Figure 19). However, one respondent indicated that they directly controlled only 15% of their industrial portfolio, with the remaining 85% being controlled by the energy user. This was due to the respondent's portfolio being dominated by highly manual industrial processes.

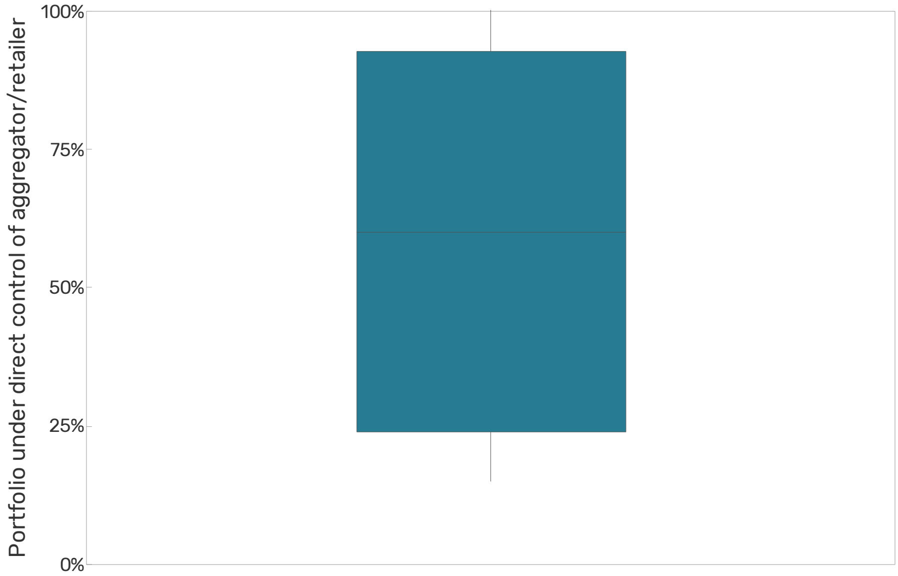



Figure 19: Percentage of industrial demand response portfolio under direct control of aggregator/retailer. N = 4.

### 4.3.2 Response characteristics

Industrial energy users tend to be significantly more varied than energy users in the commercial and residential sectors. In order to capture this nuance in the industrial sector, survey participants were asked to weight their answers to key response characteristics by megawatts rather than providing a single average value for the portfolio. For example, a retailer that has 50% of their industrial customer's requiring a 15-30 minute notice period and the remaining 50% requiring 4-8 hours, would submit each of these answers separately.

Our preferred approach would then be to weigh each respondent's answers by the total size of their portfolios. However, many respondents were reluctant to provide portfolio sizes due to confidentiality concerns. As a result, we opted to give equal weighting to each respondent so that we could capture as much of the response characteristic data as possible. Hence, please note that all percentages in this section are "weighted by respondent" rather than "weighted by volume". "N" refers to the number of respondents that provided a response to each question.

***Notice period***

71% of respondents required one hour or more notice (see Figure 20). Industrial demand response tends to be more complicated than commercial and residential demand response, due to the need for production planning. This unique factor was one of the drivers of the higher notice period requirement.

That being said, the majority of respondents had several different notice periods within their portfolio's depending on the individual needs of the energy users they represent. This reflects the high degree of variation in the industrial sector.

Although the second most common response required a relatively high notice period (4-8 hours), no respondents indicated that they needed a notice period spanning a day or more. Similar to the residential and commercial sectors, respondents did not appear to have a strong need for day ahead notification in order to effectively facilitate demand response.

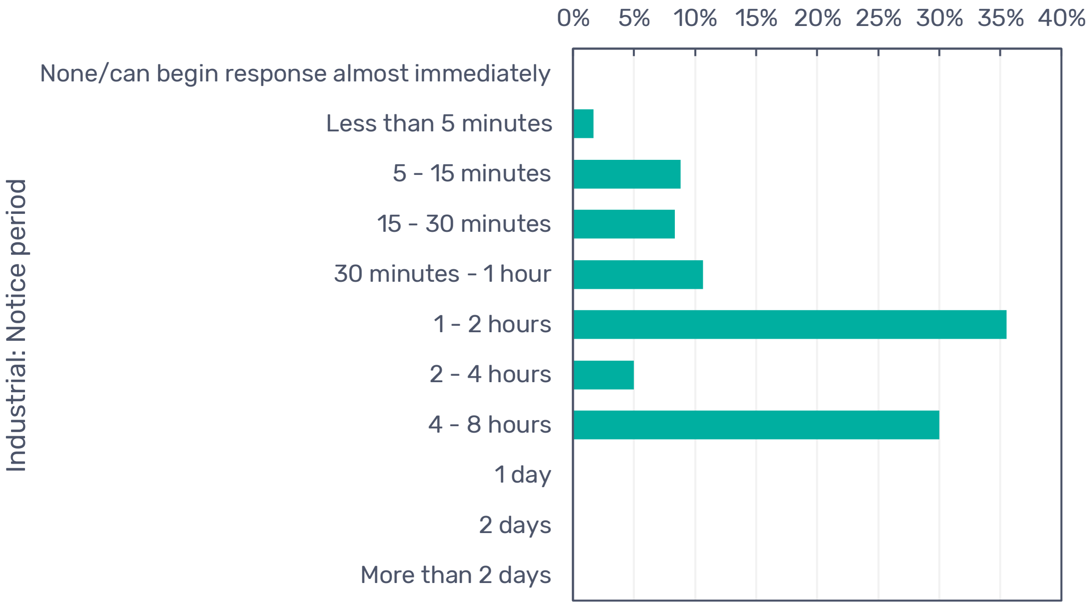



Figure 20: Distribution of notice periods required for industrial demand response. N = 6.

### *Response time*

Different types of industrial demand response required a wide range of response times, ranging from less than one minute to 1-2 hours (see Figure 21). These variations are due to idiosyncrasies of each process such as type of plant/equipment, level of automation and requirements for production planning and safety checks.

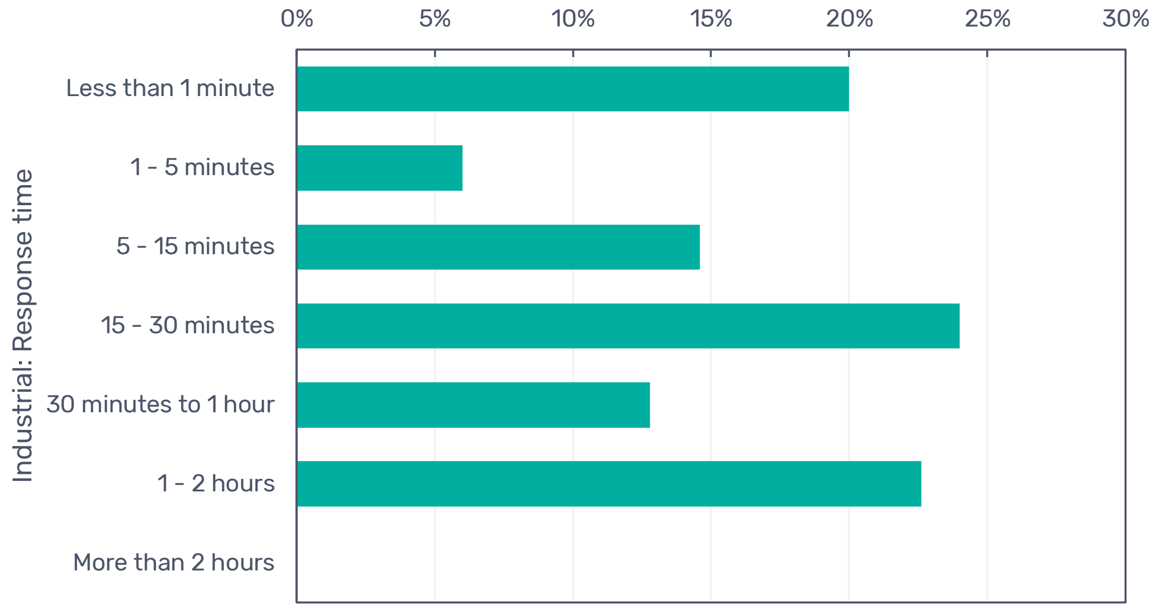



Figure 21: Distribution of response times required for industrial demand response. N = 5.

As can be seen from Figure 21, many industrial processes need more than five minutes to physically implement their full response. If demand response was bid directly into the market, the responsible market participant would likely be able to manage slower response times by ensuring that the bids for each minute period reflect the ramping capability of the portfolio.

### *Response duration*

Respondents indicated that almost all of their industrial demand response portfolios could sustain a response for at least 30 minutes. Two thirds indicated that they could maintain the full response for 2-6 hours.

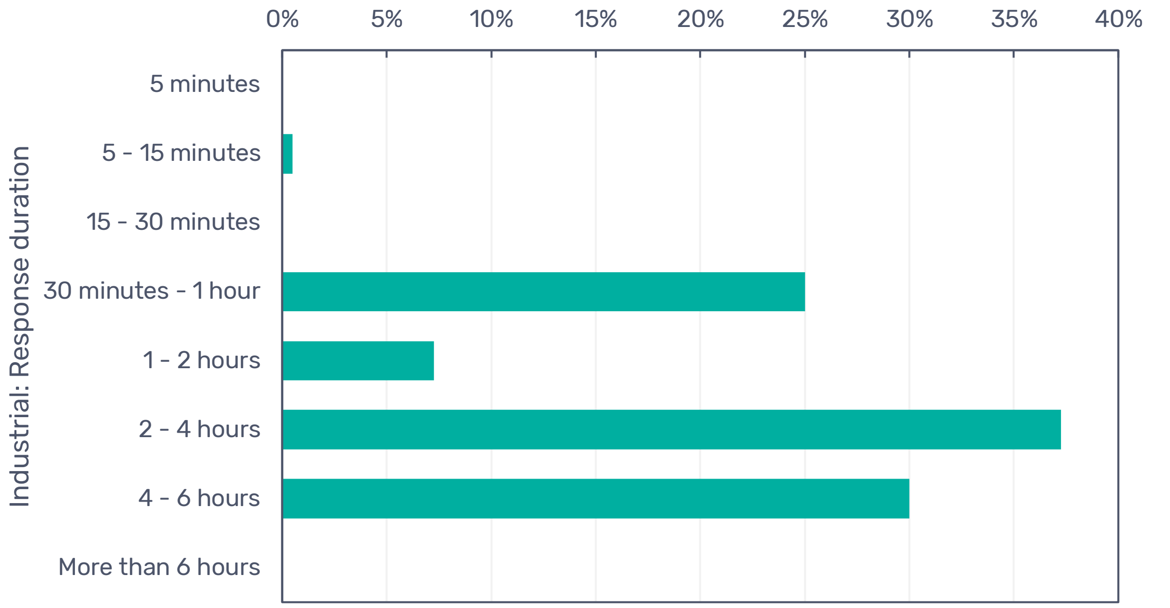



Figure 22: Distribution of response duration for industrial demand response. N = 4.

### *Physical Availability*

Somewhat surprisingly, respondents indicated that 64% of their industrial demand response portfolios could be activated at least once a day (assuming market conditions provided appropriate financial incentives).

Respondents also indicated that their industrial portfolios were less affected by seasonal and time of day/week variations compared with the residential and commercial sectors. This is because many industrial loads (especially large loads) operate continuously on a 24/7 basis. However, smaller industrial loads, which operate mainly on weekdays were identified as having similar availability restrictions as the commercial sector.

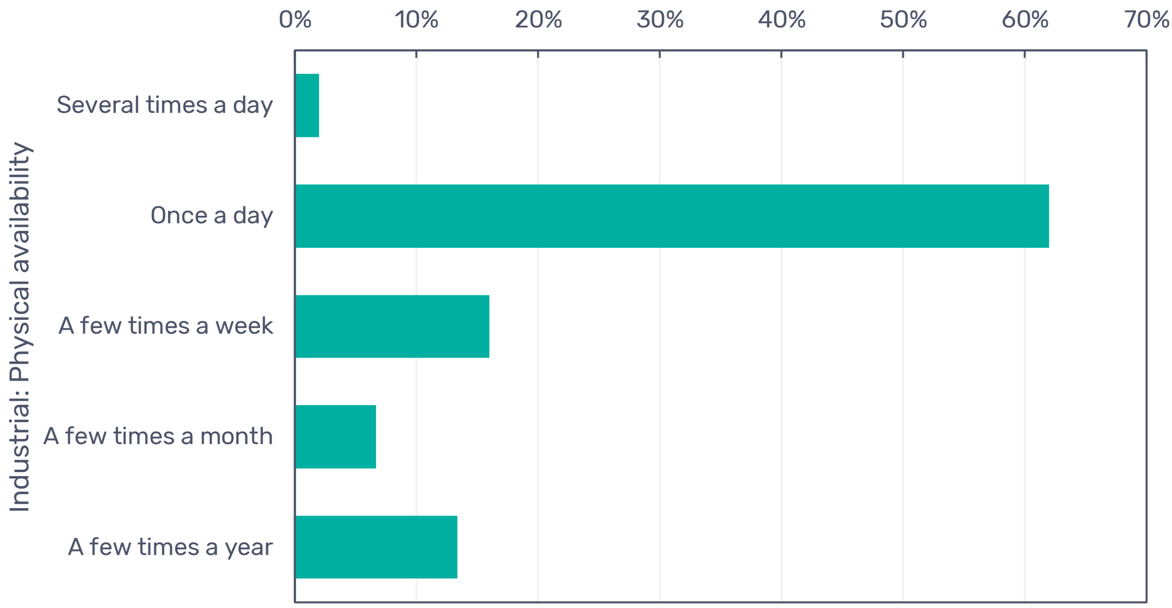



Figure 23: Distribution of physical availability for industrial demand response. N=5.

### 4.3.3 Barriers to industrial demand response

Similar to residential and commercial demand response, "financial payment not attractive enough" ranked as the biggest perceived barrier to industrial demand response (see Figure 24).

The next two barriers were "technology costs" and "not being certain of the spot price you will receive". The top three barriers all relate to the "investment decision" behind demand response. Respondents indicated that enhancing industrial demand response capability often involves substantial capital investment. Furthermore, volatility in the spot market combined with policy and regulatory uncertainty made some respondents feel that it was challenging to develop a "commercially bankable" investment case.

Getting industrial users interested in demand response was ranked as the fourth biggest barrier. Several respondents indicated that the investment decision was made more difficult by the fact that electricity trading is not core business for industrial energy users, and hence that many would prefer not to be interruptible.

While many industrial energy users do regularly provide demand response, these results suggest that improving the bankability of demand response and increasing education about the benefits of demand response, could unlock more of the potential in the market.

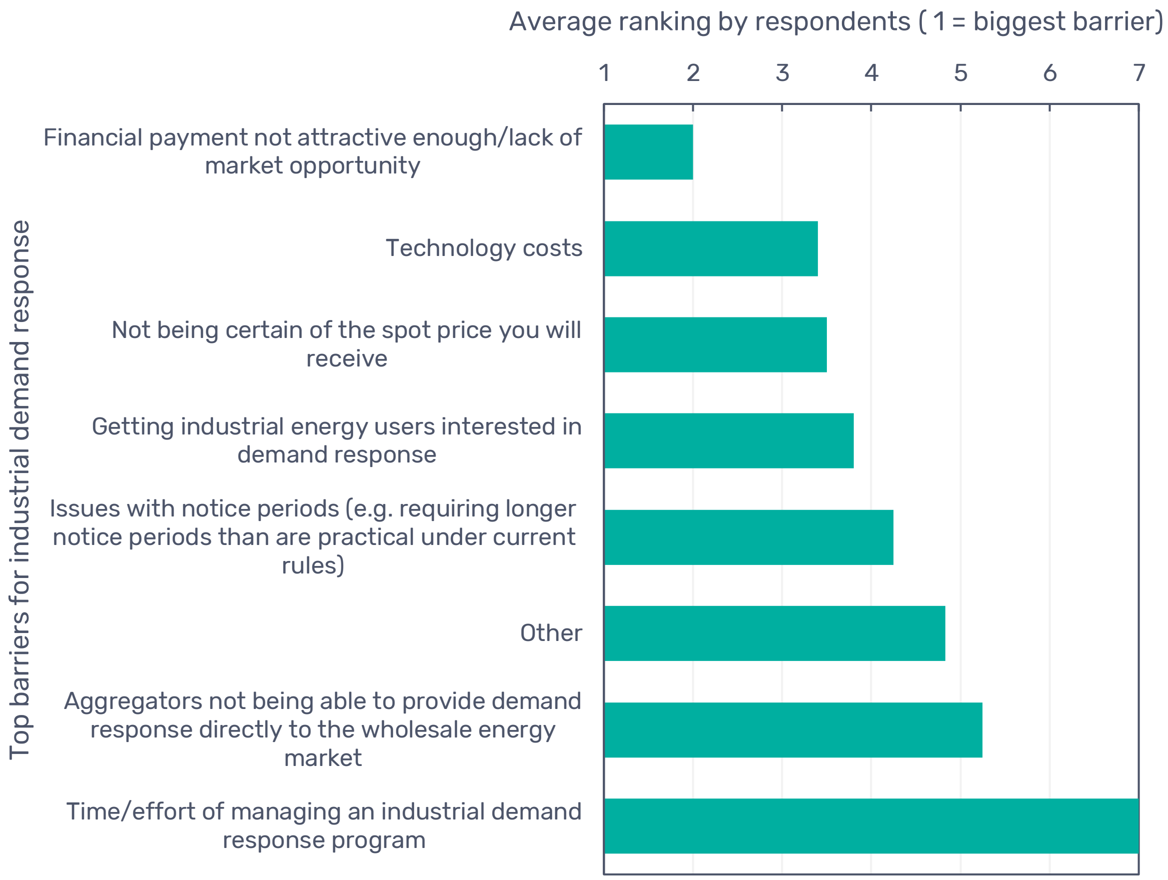



Figure 24: Average ranking for barriers to industrial demand response. Respondents were asked to rank eight barriers. The results for each barrier were then averaged. A lower average indicates that the issue was perceived as a bigger barrier. N = 5.

### 4.3.4 Trigger prices

Respondents indicated a wide range of trigger prices at which they would consider a response. Trigger prices were as low as $500/MWh and as high as >$5,000/MWh.

# 5 Case Studies

Energy Synapse interviewed selected electricity retailers, aggregators and an industrial energy user to gain a deeper understanding of how they implement demand response. These case studies are provided below.

Some key observations include:

(a) Retailers and aggregators strongly believed in offering customers choice over what resources are controlled and the ability to manually override an intended response if needed. The voluntary nature of how demand response works in practice is important to emphasise as there can be a misconception that demand response is something that is 'forced' on energy users. Some aggregators also had internal strategies, such as oversubscribing demand response programs, to help manage the risk of under delivery during a demand response event, while still providing their customers with adequate flexibility.

(b) The most common barriers related to building a bankable investment case for demand response. Technology costs coupled with low revenue certainty and often low understanding of demand response were seen to make the investment decision more challenging. Some aggregators thought that a rebate for installing hardware/control equipment would make the investment decision easier to understand by customers. Other respondents indicated that capacity style payments could help firm up businesses cases by overcoming the uncertainty of payments in the spot market.

(c) There was a commonly shared view that creating baselines to measure the response for the residential sector would be challenging. For example, consumers who take regular action to reduce their energy usage from 6pm-8pm could be disincentivised from participating in a demand response mechanism as their baseline would potentially be very low.

(d) When it comes to market reform, retailers and aggregators also expressed common concerns related to requiring loads to be fully scheduled in the same way as generators, with the belief that this would lock out a significant portion of energy users who have flexible loads.

(e) Retailers/aggregators were generally strongly in favour of automation stating that it would reduce risks to market participants, enable shorter notice periods to be used, and ultimately result in higher cost savings for energy users.

## 5.1 Residential case studies

### 5.1.1 Intelligent Automation

***About Intelligent Automation***

Intelligent Automation's Gswitch is a Home Energy Management System that creates greater efficiency of power use in domestic and commercial environments with no loss of day to day functionality [4].

In a residential context, Intelligent Automation is able to control a large variety loads including air conditioning, hot water, pool pumps, pool heating, hydronic heating and cooling, floor heating, electric vehicles, and general appliances, as well as solar PV. This gives Intelligent Automation the ability to control the import/export at the NMI level and hence the ability to provide demand response in terms of both reducing load at high prices and increasing load at low or negative prices.

Due to the large variety of loads under control, Intelligent Automation is able to control ≥85% of its residential load portfolio. Two thirds of the load under control is air-conditioning.

***How demand response is implemented***

Intelligent Automation operates under a subscription model, where consumers are charged an ongoing fee for active management of their load profile.

The Gswitch is installed by a qualified and approved electrician into the home's switchboard. Consumers are given access to a personalised online Dashboard, accessed via a smart phone, tablet or computer, which gives complete control over the operation of the Gswitch including all functions and settings. It also provides real-time information about power consumption and solar generation.

Consumers are given the ability to choose which loads will be controlled and the price points at which loads will be turned off. Consumers also have the ability to manually override any intended response from the aggregator.

Examples of specific demand response initiatives are provided below.

Responding to wholesale energy prices
For consumers who are exposed to the wholesale price via their retailers, Intelligent Automation is able to manage this exposure on behalf of the consumers. Intelligent Automation's software assesses the price opportunity in the market and presents a "sliding window" opportunity to reduce load at high prices and increase load at low prices (for example selecting the cheapest time for charging electric vehicles). Intelligent automation is currently testing live triggers for spot prices.

Note that Intelligent Automation's software works on behalf of the end consumers, rather than aggregating a portfolio on behalf of a retailer.

Managing demand charges
Intelligent Automation software works proactively to minimise maximum demand charges for consumers. For example, if a customer starts cooking and hence raising their demand, the software automatically monitors this and begins turning down other load such as air conditioning.

Energex Home Energy Management Systems (HEMS) pilot
Intelligent Automation is part of the HEMS pilot in and around Brisbane, which is targeting 500 consumers to join the program. The function of Intelligent Automation in the trial is to help manage voltage issues, which arise from reverse flows from solar PV systems and to pinpoint any problems as they happen.

Intelligent Automation provides the DNSP with the ability to target a feeder, street, or specific NMI, without having to perform physical work on the network.

***Thoughts on automation***

Intelligent Automation expressed a very strong view that high uptake of residential demand response would require a largely automatic response. Intelligent Automation believes that consumers are unlikely to persist with behavioural changes in the long term.

| |
|---|
| ***Perceived barriers to demand response***<br><br>Intelligent Automation ranked the "financial payment not being attractive enough/lack of market opportunity" as the biggest barrier to residential demand response. Intelligent Automation also felt that selling consumers on the concept of demand response was made more difficult by the fact that they cannot say exactly how much a customer would save over 12 months by installing a device.<br><br>The second biggest barrier was "engaging with customers and getting them interested in demand response". Intelligent Automation expressed challenges in shaping consumer perceptions as many consumers are not aware of what demand response is and are resistant to the concept of having loads turned off. Intelligent automation identified a need for greater education in the sector about demand response and the need to "dangle a carrot" to give consumers a clearer benefit (for example receiving a rebate for installing a control device). |
| ***Comments on market reform***<br><br>Intelligent Automation expressed a strong view that the incentives of third-party aggregators were better aligned with consumers than that of retailers and that hence aggregators should be the party that controls the load. As a result, Intelligent Automation believes that allowing residential aggregators direct and free access to the wholesale market is an important market reform.<br><br>In creating an open market for load control, Intelligent Automation thought that baselining and calculating demand response reductions would be a challenging issue requiring careful consideration.<br><br>Intelligent automation also expressed a view that government feed-in-tariffs were distorting market signals and hence preventing greater uptake of residential demand response. For example, when wholesale prices are negative, consumers could still be receiving a feed-in-tariff which reduces the incentive to consider load control. Intelligent Automation believes that by giving aggregators access to the market price, will significantly incentives solar soaking and load control. |
| ***Views on the potential of residential demand response***<br><br>Despite having the ability to control batteries, Intelligent Automation felt that battery storage was still too expensive to have a real return at present and that load control should be the first line of defence.<br><br>Intelligent Automation believes that there is a massive amount of untapped potential in the residential sector due to a very large portion of consumers having air-conditioning and hot water. |

### 5.1.2 Amber Electric

***About Amber Electric***

Amber Electric provides a retail energy product, which passes through the wholesale price of electricity directly to residential consumers.

Approximately 97% of Amber Electric's demand response portfolio comes from behavioural demand response, rather than an automated/direct control response.

Amber's customers respond to wholesale prices by manipulating several loads such as air conditioning, hot water, battery storage, electric vehicles, and pool pumps.

As Amber passes through the wholesale price, they do not benefit directly from customer's providing demand response. Rather, this provides consumers the opportunity to take direct control of their electricity costs.

***How demand response is implemented and views on future potential***

Amber facilities demand response by giving consumers direct access to real time price signals in the wholesale market.

All Amber customers have access to a mobile app, which provides high pricing alerts, which are predominately based on pre-dispatch forecast pricing. Customers receive push notifications and emails alerting them of high pricing. Depending on the predictability of the high pricing events, customers will sometimes receive a notice period, while at other times a more immediate response is encouraged.

Amber customers also have the ability to create custom alerts for negative or low prices, which encourage consumers to increase their electricity usage.

Being a behavioural demand response program, any response from consumers is completely voluntary.

Amber communicates consumer savings relative to the default offer on a 30 day as well as lifetime basis. Amber also communicates how much renewable energy consumers are using from the grid. This helps to keep motivation up in a largely behavioural program.

In the 2019-20 summer, Amber estimates that upwards of 50% of its customer base was providing meaningful demand response. Typically, Amber's portfolio is able to achieve a 20-30% load drop during a high price event.

Amber estimates that this represents about 30-50% of the potential flexibility that exists in their portfolio. Amber believes that this untapped potential could be unlocked with a combination of higher automation and better foresight tools to give consumers more notice.

***Thoughts on automation***

Although Amber Electric has had success with facilitating behavioural demand response, Amber expressed a view that higher automation could unlock more demand response. Amber believes that a wholesale price pass through model is well placed to cater to both behavioural and automated demand response, but that the future was likely to be more automated.

***Perceived barriers to demand response***

Amber did not feel that there were strong barriers to residential demand response, as the Amber business model already unlocks a major barrier, which is consumers not having access to the wholesale price.

That being said, Amber felt that higher smarter meter penetration and a cost reduction in smart devices would unlock further demand response.

***Comments on market reform***

Amber expressed a view that calculating baselines for the residential sector would be very challenging. For example, consumers who are already being proactive and taking action daily between 6pm and 8pm, could end up having a very low baseline in a demand response mechanism, which would act as a disincentive to participate.

Amber believes that giving consumers a real time price signal is the most efficient way to facilitate demand response. Amber has found a way to do this without a formal demand response mechanism, however is not opposed to such a mechanism operating in parallel with the Amber model.

## 5.2 Commercial case studies

### 5.2.1 Enel X

***About Enel X***

Enel X is an aggregator of commercial and industrial demand response. Enel X offers its customer portfolio's combined load flexibility to the market, system operator and network businesses.

Enel X works across various industries including hospitals, data centres, agribusiness, cold store facilities, water utilities, shopping centres and more to harness the site's load flexibility from backup generators, battery storage systems, or energy intensive equipment.

These distributed energy resources are called on to support the grid when needed, either by powering down temporarily or switching from grid power to onsite generation or storage systems. This earns participating businesses a new revenue stream from existing assets that are typically a sunk cost.

More than half of the commercial demand response portfolio is directly controlled by Enel X as opposed to the energy user enacting a manual response.

***How demand response is implemented***

Enel X has an agreed framework with customers in order to implement different types of demand response, while taking into account unique customer needs. An important aspect of this is that Enel X gives customers the flexibility to opt out if they cannot provide the required response. As an aggregator, Enel X manages this risk by giving themselves a buffer and oversubscribing their demand response programs. This helps to manage the risk of financial penalties as well as reputational risks that come with being a market participant.

Enel X helps its customers in the NEM access several forms of demand response. Examples are given below.

Responding to wholesale energy prices
Enel X uses the Small Generation Aggregator (SGA) framework to allow commercial energy users to use backup generators to access the wholesale price and turn on generators when prices are high.

Frequency Control Ancillary Services
Enel X is registered as a Market Ancillary Services Provider (MASP) in FCAS markets. Due to the nature of FCAS markets, Enel X's commercial portfolio provides an automated response.

RERT
Enel X is an aggregator in the Reliability and Emergency Reserve Trader (RERT) scheme. The type of energy users that participate in RERT tend to require some notice before a dispatch and may have a manual rather than automated process.

Managing demand charges
Enel X utilises customer's load flexibility to optimise tariffs and reduce maximum demand charges.

Echuca Regional Health Case Study
Enel X provided a specific example of how one of their customers, Echuca Regional Health has approached demand response [5].

Echuca Regional Health has one of the largest solar thermal arrays in Australia, providing not only heating but also absorption cooling to the hospital's high efficiency HVAC system, 1.2MW of thermal energy storage which is utilised for peak demand management, and a new 500kW solar photovoltaic array that is currently underway. The hospital has also been utilising its backup generators to participate in a Virtual Power Plant (VPP) – a collection of distributed energy assets including backup generators, batteries, and flexible loads that work together to provide additional dispatchable capacity to the grid – since 2017.

***Thoughts on automation***

Enel X expressed a view that there were strong advantages with increasing automation as this would help mitigate some of the risk on the customer side. Greater automation would make implementation of commercial demand response easier.

| |
|---|
| ***Perceived barriers to demand response***<br><br>Enel X noted that some barriers, such as retailers controlling the relationship with the customer, were gradually being addressed by policy makers. This includes the introduction of the wholesale demand response mechanism in October 2021 and more substantive reforms being explored by the Energy Security Board to introduce a two-sided market.<br><br>Enel X also noted that uptake of demand response could be improved by having technology requirements that are proportionate to the risks/need and having greater certainty on potential revenue streams and value in order to firm up the investment case for demand response.<br><br>Enel X also viewed cumbersome application and registration processes as barriers. For example, the generator exemption process (which is needed to enrol a generator in the SGA framework) was flagged as being challenging, especially for multiple generators that are co-located with load. This was viewed as a significant barrier to entry for SGA participants with these types of customer sites.<br><br>Lastly, Enel X has observed that many people still do not have a strong understanding of what demand response is. This is compounded when the decision makers in an organisation are not close to the energy management function, which can further complicate the investment decision. |
| ***Comments on market reform***<br><br>Enel X expressed a view that the wholesale demand response mechanism coming into effect in 2021 will help to capture more of the potential commercial capability that exists in the NEM. However, the wholesale demand response mechanism and the SGA framework were viewed as only suitable for a defined pool of customers. There is likely to be an even wider pool of potential customers who cannot be accessed by independent aggregators without further regulatory reform. A specific regulatory barrier that would need to be overcome is not requiring demand response to be fully scheduled in the same way as generators. |
| ***Views on potential for demand response***<br><br>Enel X has estimated that there is approximately 2.5 GW of existing assets waiting to be tapped in the commercial and industrial sectors. This includes capability in backup generators, pumps, chillers and compressors.<br><br>Enel X notes that not all of these assets will necessarily be suitable for demand response participation. This will depend on whether the conditions are right for each individual customer, but this figure provides a general sense of the scale of potential flexibility that exists. |

### 5.2.2 Flow Power

***About Flow Power***

Flow Power is an electricity retailer who helps Australian businesses unlock value from the wholesale energy market. Flow Power offers products that were traditionally available to market participants rather than end users (for example, spot pass through and various hedging instruments).

Flow Power predominately utilises embedded/backup generation to provide commercial demand response. Flow Power directly controls approximately 20% of their commercial demand response portfolio, with the remaining 80% requiring a manual response from energy users.

***How demand response is implemented***

Flow Power helps to facilitate several different types of demand response on behalf of their customers.

RERT
Flow Power has participated in the RERT since 2017.

Ausnet Critical Peak Notification
Flow Power adds value to customers by giving greater notice as to when critical peak events are expected to occur and also providing reporting services after the fact. Flow Power expressed interest in taking a greater role in facilitating network services, but noted that the process for contracting network deals tended to be very opaque and difficult.

Responding to spot prices
The majority of Flow Power's customer who provide wholesale demand response are spot exposed. A smaller portion have what are called "price shape" contracts.

At a high level, Flow Power follows the process below to implement wholesale demand response:

1. Flow Power provides customers with a high level weekly forecast of where spot prices could be.

2. On a day ahead basis, Flow Power examines pre-dispatch prices and advises customers if they believe that high pre-dispatch prices are credible.

3. Flow power sends notifications via SMS and email closer to the expected event/ Most customers are manual and hence require a 30 minute to 1 hour notice period. However, providing this can be challenging due to the volatility/uncertainty in the market.

4. Flow Power send an 'end of event' notification telling customers that the market has returned to normal.

5. Flow Power provides post event reporting that tells customers the load reduction and cost saving that was achieved. This is seen as an important step in communicating the value of demand response to customers.

Flow Power also provides post event reports that tell customers what load reduction and cost saving has been achieved. This is seen as an important step in communicating the value of demand response to customers.

***Thoughts on automation***

Flow Power expressed a strong view that "automation is king". Demand response could be implemented more effectively if energy users were more automation. Automation could also overcome some of the challenges with providing notice periods.

| |
|---|
| ***Perceived barriers to demand response***<br><br>Engaging with customers and overcoming harmful but inaccurate perceptions was seen as a major barrier to commercial demand response. For example, Flow Power observed that many energy users had an inaccurate perception that demand response required a full shutdown, without understanding that a partial response could be utilised as well. Flow Power's experience was that there were also a range of customers who simply prefer to not be interruptible.<br><br>Engaging with energy users is made more challenging when they are large commercial organisations. This is because there are often many stakeholders to work with, who may not be close to the energy management function, which makes the approval process more challenging.<br><br>Flow Power also recognised the need for those in the energy industry to communicate the risks and opportunities of demand response more effectively.<br><br>The commercial sector was also viewed as being more challenging from a technology perspective, because it is much more varied than the residential sector (which is relatively homogenous). This higher variation presents challenges when it comes to developing a standardised tech product. As a result, the cost of technology can be barrier as 'one size does not fit all'. |
| ***Comments on market reform***<br><br>Flow Power felt the biggest challenge with the wholesale demand response mechanism was the obligation on loads to be scheduled in the same way as a generator. This would need to be overcome in order to unlock a higher amount of demand response. |
| ***Views on potential for demand response***<br><br>Flow Power was very optimistic about the potential for demand response and believes there are several gigawatts of untapped flexibility in the commercial and industrial sectors in the NEM. |

## 5.3 Industrial case study

### 5.3.1 Tomago Aluminium

| |
|---|
| ***About Tomago Aluminium***<br><br>Tomago Aluminium is Australasia's largest aluminium smelter, producing 590,000 tonnes of aluminium per year (~35% of Australia's primary aluminium). Tomago Aluminium is an independently managed joint venture between Rio Tinto, CSR and Hydro Aluminium.<br><br>Aluminium production relies on electricity to power the process 24 hours per day, 365 days per year. Tomago Aluminium uses approximately 10% of the power generated in NSW.<br><br>The aluminium production takes place in potlines. Tomago Aluminium has three potlines with 840 pots in total. A substation on-site supplies electricity to the pots, which are connected electrically such that current flows through one pot onto the next. The electricity flows through the anodes (carbon blocks that are suspended in molten electrolyte) and causes the alumina to separate into its constituent elements - aluminium and oxygen [6].<br><br>Each potline consumes approximately 300 MW of power. Tomago Aluminium provides demand response by taking up to two pot lines completely offline or ramping down power usage (~50 MW per potline).<br><br>The production process is highly automated and requires a "one button push" to initiate a shutdown of a potline. |
| ***How demand response is implemented***<br><br>Tomago Aluminium is primarily involved in two types of demand response: the RERT program and responding to high spot prices via a contractual arrangement with the electricity provider.<br><br>Tomago has an internal team who proactively monitor the energy market, which gives Tomago a good sense of when demand response may be needed. Tomago also noted that historical communications with AEMO and their electricity retailer have been very good. As a result of these two factors, Tomago said it was rare to receive unexpected/problematic demand response requests.<br><br>Tomago noted that one-hour notice is generally sufficient to be able to prepare for an event and take precautions, such as modifying the chemistry in the pots to minimise the recovery time should an interruption be called.<br><br>During a demand response event, Tomago prefers to take one potline offline at a time. However, in an emergency situation, it is possible for Tomago to take approximately 600 MW off the grid (two potlines simultaneously) in less than a minute. Tomago has also undertaken modelling to investigate how a full site shutdown could be achieved in an emergency.<br><br>Tomago noted that their ability to provide a response is also influenced by the frequency of interruptions. For example, if Tomago has not experienced any interruptions in the previous two weeks, then it is generally not considered problematic to turn off a potline. |

However, consecutive interruptions within a short time frame are considered more challenging.

When it comes to responding to high spot prices, the contractual provisions with the retailer mean that Tomago would become exposed to the spot price (i.e. unhedged) if load was not reduced when asked by the retailer. Hence, this provides the risk/reward mechanism that Tomago balances when making a demand response decision.

***Unique process risks and how this impacts approach to demand response***

The main risk that Tomago Aluminium faces when providing demand response is the pots freezing. This would be a very significant cost for the business.

Tomago noted that potlines will freeze in approximately two hours and fifty minutes. This has two major implications.

Firstly, it affects the duration of the response that Tomago Aluminium is able to provide. Tomago Aluminium prefers to limit interruptions to one hour as this gives a buffer to trouble shoot the restart process. Tomago noted that re-energising the potlines is a considerably more complex process than the initial shutdown. The response duration could theoretically be extended to two hours in an emergency situation, but this would significantly reduce the margin of error in the restart process and would also extend the recovery time. Tomago noted that it can take up to eight weeks to stabilise the potlines after an unplanned interruption.

Secondly, the risk of potlines freezing means that Tomago Aluminium sees a crucial risk mitigation role for itself in helping to maintain the stability of the NSW grid. Internal modelling from Tomago has found that if a system black event were to occur in NSW, it could take five hours for power to be restored. As a result, Tomago believes it is in their interest to provide an interruptible load service rather than risking the very high cost of pots freezing.

***Perceived barriers to demand response and comments on market reform***

Tomago Aluminium responds to spot prices under a contractual model where payments are based on if and when demand response events occur. The contingent (per event) nature of the payments makes them very difficult to include in annual business planning.

As more variable renewable energy connects to the grid, and ageing coal-fired power stations retire from the market, Tomago see themselves being called upon more frequently by their retailer and AEMO to provide demand response. In order to be able to respond more frequently, Tomago would likely need to invest in electrical infrastructure to make the site more reliable. However, the uncertainty that comes with contingent/variable payments makes it difficult to build a bankable business case and hence this was perceived as the biggest barrier to demand response.

Tomago noted that a capacity style payment, which is known with certainty at least one year in advance would provide the firmness needed to make investment decisions.

Tomago also emphasised that receiving appropriate notice of demand response events was important. However, this was being managed relatively well by Tomago's retailer as well as Tomago's own internal team, which monitor the market. In this context, Tomago

| |
|---|
| did not see a significant benefit in having a day ahead market (or ahead markets more broadly). |

# 6 Analysis of spot prices in the NEM

## 6.1 Historical frequency of high price events

Energy Synapse has analysed 30 minute spot prices in each region of the National Electricity Market (NEM) over the last three financial years.

We first determined how many 30 minute Trading Intervals had a spot price greater than or equal to $300/MWh. This is shown in Figure 25.

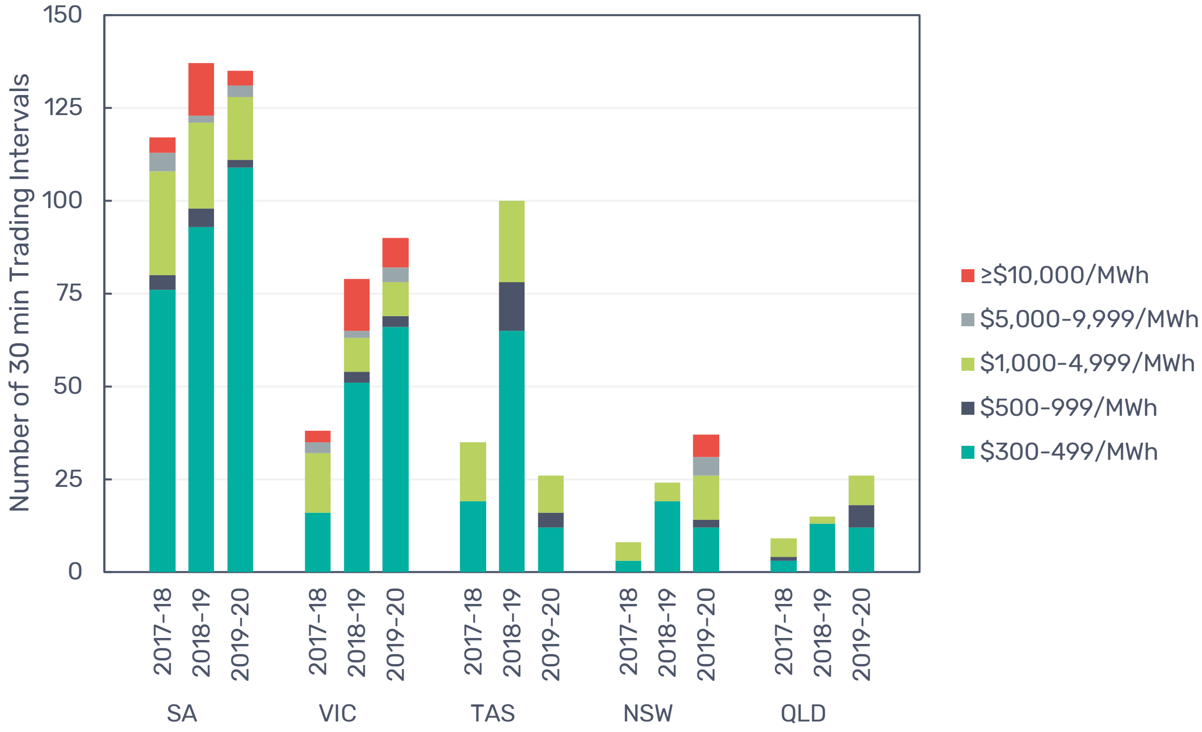



Figure 25: Number of 30 minute Trading Intervals where the spot price was greater than or equal to $300/MWh.

As can be seen from Figure 25, the most commonly occurring 'high price' event was between $300 and $500/MWh in all regions. In contrast, extreme price spikes tend to be much less common.

South Australia has had significantly more ≥$300/MWh price events than any another region. This has been predominantly due to having a 'peaky' load profile, weaker interconnections with the rest of the NEM, and an over-reliance on firming from gas generation.

In contrast, NSW and Queensland have had the lowest number of intervals where prices were greater than or equal to $300/MWh.

In terms of extreme price spikes, Victoria had the most trading intervals where the spot price was ≥$10,000/MWh (25 intervals over three years). In contrast, spot prices in Tasmania and Queensland have not exceeded $5,000/MWh at any time in the last three financial years.

We also examined how often prices between $200 and $300/MWh occur (see Figure 26). We anticipate that there may be a future appetite for market participants to use Virtual Power Plants (VPPs) to defend $300 cap style contracts. If so, they may be activating VPPs in this price range.

Prices between $200 and $300/MWh occurred almost five times more frequently than prices ≥$300/MWh over the last three financial years. The high frequency of these events means that demand side technologies that can be cycled more frequently (such as battery VPPs) would be best placed for this application.


Figure 26: Number of Trading Intervals where the spot price was $200-299/MWh.

## 6.2 Distribution of high price events and implications for demand response

We examined how high prices events are distributed in more detail in order to draw out potential implications for demand response.

Figure 27 shows two important dimensions. On the horizontal axis, we have the length of the price event within a single day (note that these may not necessarily be consecutive). On the vertical axis, we have the number of days corresponding to each price event duration.

For example, over the last three financial years, Tasmania has had 55 days that had only one 30 minute Trading Interval where the spot price was ≥$300/MWh.

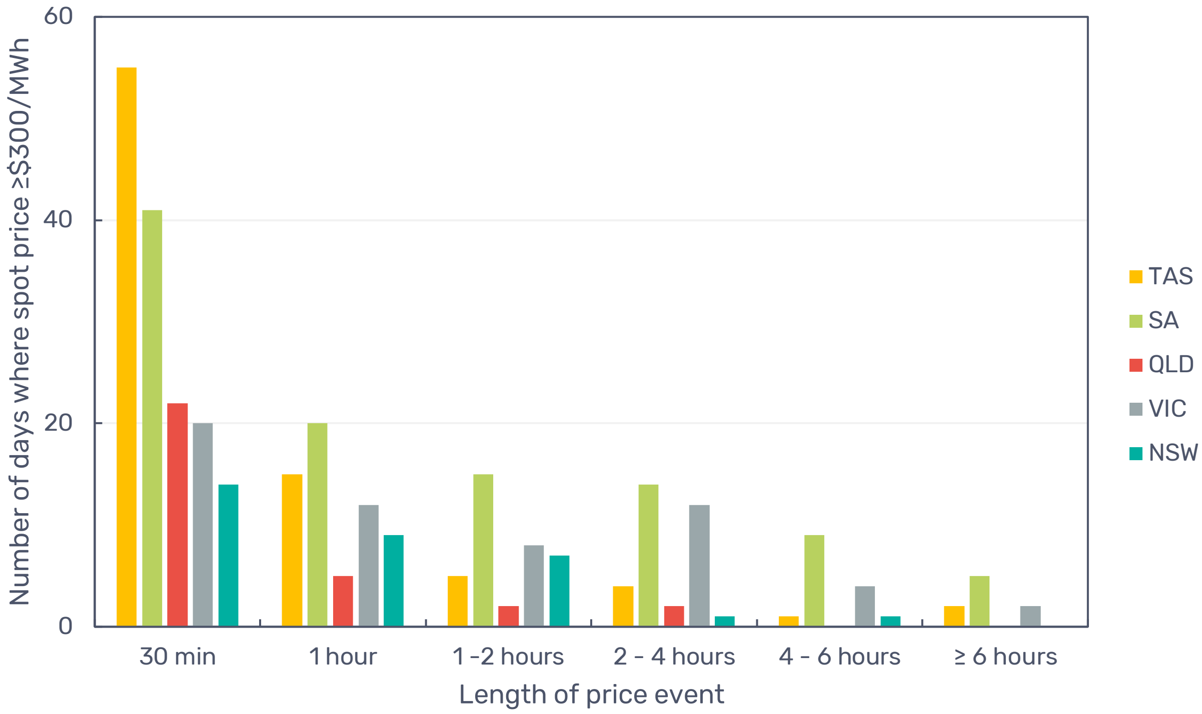



Figure 27: Analysis of how long high price events (≥$300/MWh) last for. Data is the total from 1 July 2017 to 30 June 2020.

Prices ≥$300/MWh occur most commonly as a stand alone 30 minute Trading Interval in a given day in all regions of the NEM. This means there could be a significant opportunity for shorter duration demand response (such as that provided by battery storage).

Demand response with a duration of two hours would be able to capture almost all high price events in NSW, Queensland, and Tasmania. There could a role for longer duration demand response (2 – 4 hours) in the Victorian and South Australian markets.

Extreme price events (≥$5,000/MWh) occur relatively infrequently, but can have a disproportionate impact on the total energy costs paid by consumers.

Figure 28 shows the characteristics of all prices ≥5,000/MWh. Figure 29 isolates prices ≥$10,000/MWh. Each dot represents one day. The vertical axis shows how long these high prices lasted for in that day. Note that when prices are ≥$5,000/MWh, they almost always occur consecutively.

Our analysis shows that demand response with a duration of two hours could be utilised in approximately 70% of hours where the spot price is ≥$10,000/MWh. This percentage remains constant when we consider all prices ≥$5,000/MWh.

In contrast, demand response with a duration of one hour could be utilised in approximately 55% of hours where the spot price is ≥$10,000/MWh. This reduced to 47% when we consider all prices ≥$5,000/MWh.

Prices ≥$5,000 almost always occurred during the first quarter of the year (January to March). Despite the seasonal concentration of these events, their relatively low frequency means that most forms of demand response (including industrials) would likely to able to consider responding (assuming appropriate market and contractual arrangements).

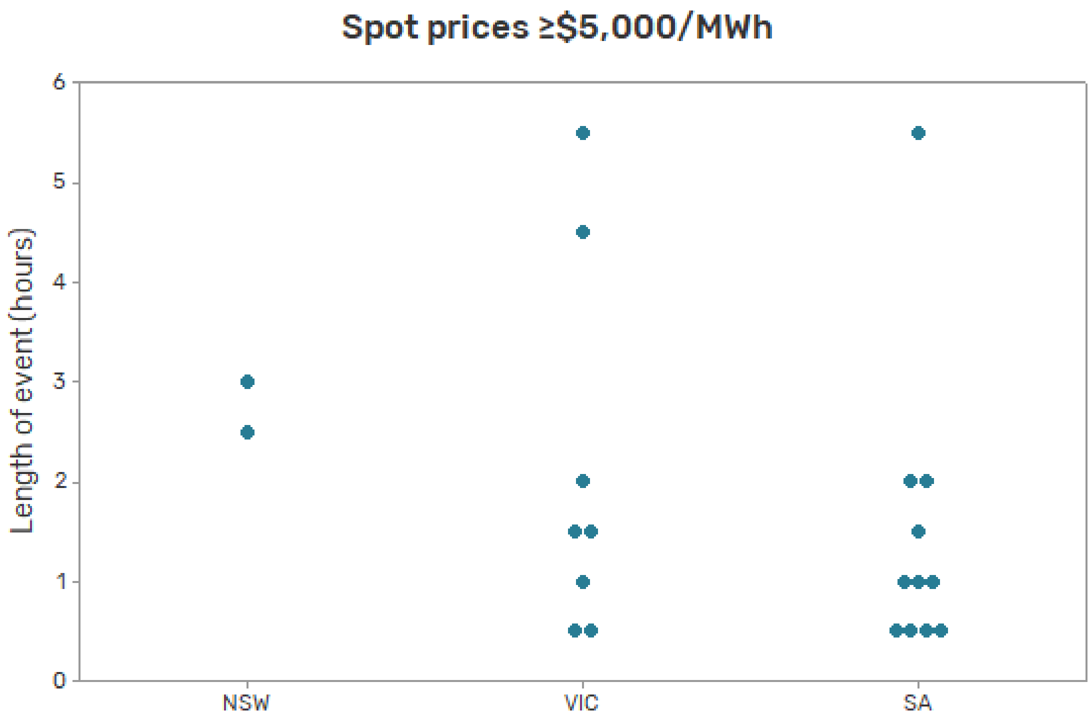



Figure 28: Number of days that had a spot price ≥$5,000/MWh. Data is the total from 1 July 2017 to 30 June 2020.

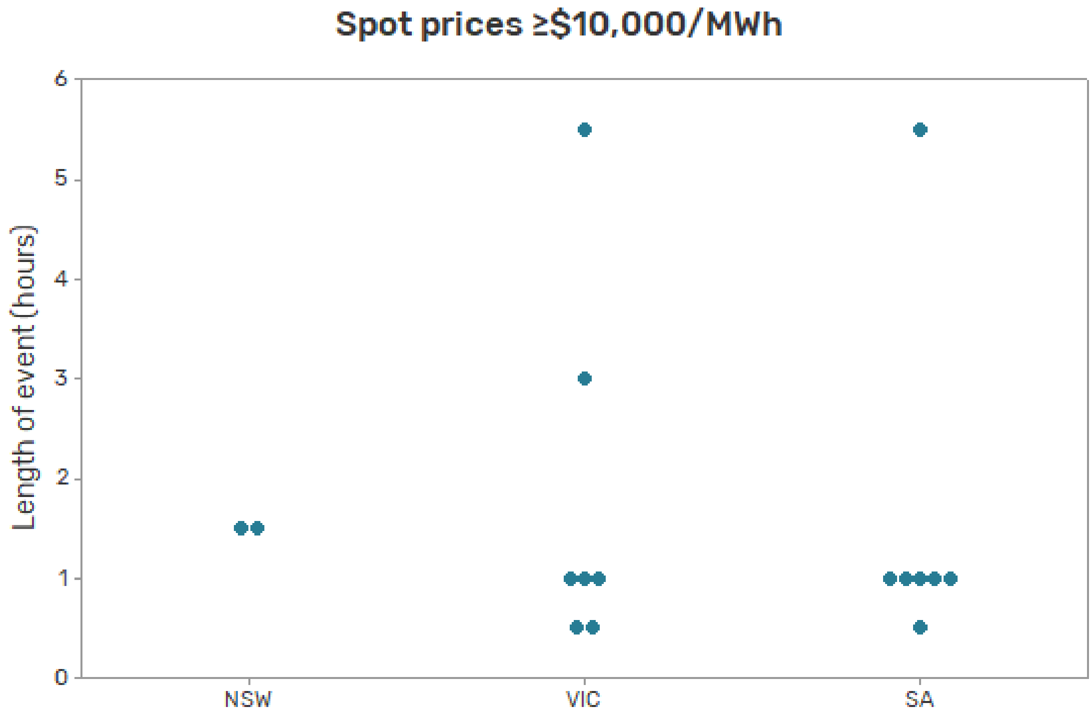



Figure 29: Number of days that had a spot price ≥$10,000/MWh. Data is the total from 1 July 2017 to 30 June 2020.

In Figure 30, we examined pricing between $200 and $300/MWh. As was the case for prices ≥$300/MWh, prices $200-300/MWh occur most often as a single 30 minute Trading Interval in a day. However, there may be stronger opportunity for demand response with a longer duration (2-4 hours) in this price range.

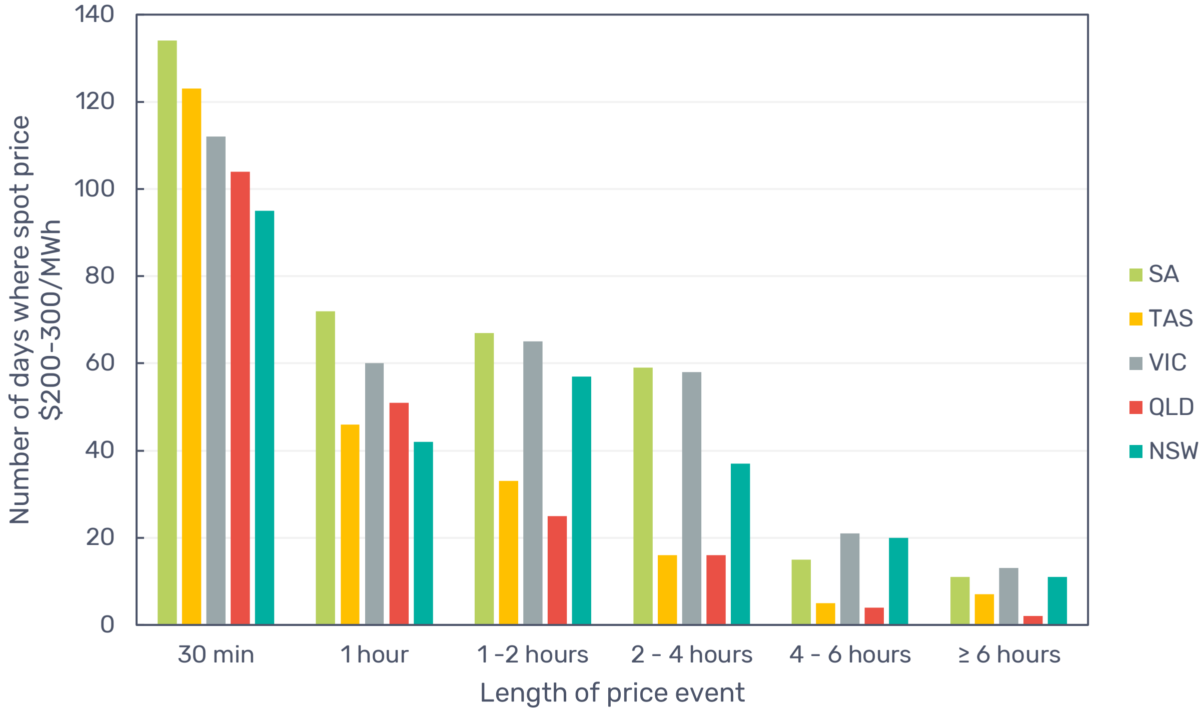



Figure 30: Analysis of how long $200-300 price events last for. Data is the total from 1 July 2017 to 30 June 2020.

# 7 Analysis of generator bidding behaviour

Energy Synapse analysed the generator bidding behaviour in each region of the NEM to gauge the sensitivity of prices under different conditions. This sheds light on the potential price suppression role of demand side participation in the NEM.

Generator bidding behaviour changes dynamically on a five minute basis to reflect the operational circumstances of individual generators and evolving market conditions. We analysed the five minute bids for the last three financial years for each generator using AEMO's NEMWEB Data [6]. We examined the bidding behaviour at different price levels, starting at $200-300/MWh. The charts on the following pages show the median volume that was offered under various price outcomes.

As expected, generator bid stacks followed the characteristic "hockey stick" shape. High volumes were offered at low prices (<$100/MWh). There tended to be a relatively small amount of volume offered at mid-level prices, before reaching the >$10,000/MWh band. The steeper the bid stack, the greater the opportunity for demand response to put downward pressure on prices, because a relatively small volume can have a large price impact.

More detailed analysis is provided below for each individual NEM region. Please note that opening up the wholesale market to demand response providers will likely change the bidding behaviour in the market. Therefore, care must be taken when interpreting historical data as it may not reflect future conditions.

## 7.1 New South Wales

(a) Over the past three financial years, NSW has had the steepest bid stack out of any region in the NEM. When the dispatch price was between $200/MWh and the market cap, a median volume of 0 MW was offered at bid prices of $500-10,000/MWh.

(b) When the dispatch price increases to ≥$500/MWh, more volume has generally been offered in low price bands (<$100/MWh). As a result, mid-level bids begin to disappear and hence the generator bid stack gets progressively steeper.

(c) When the dispatch price in NSW is $500-10,000/MWh, it is likely that this price is often being set by generators outside of NSW (given the lack of bids in this range by NSW generators). If energy users in NSW were to offer demand response, it could mean that the NSW price could clear at a lower level, rather than relying on imports from more expensive interstate generators.

(d) When the dispatch price was greater than or equal to $10,000/MWh, a median volume of 0 MW was offered between $200 and $10,000/MWh in all three financial years. In the 2019-20 financial year, no volume was offered between $100-10,000/MWh. This presents a significant opportunity for a variety of demand side resources to potentially undercut generators and lower energy costs for all consumers in the market.

(e) Note that a blank bar in Figure 31 means that there were no prices at that level in that financial year.

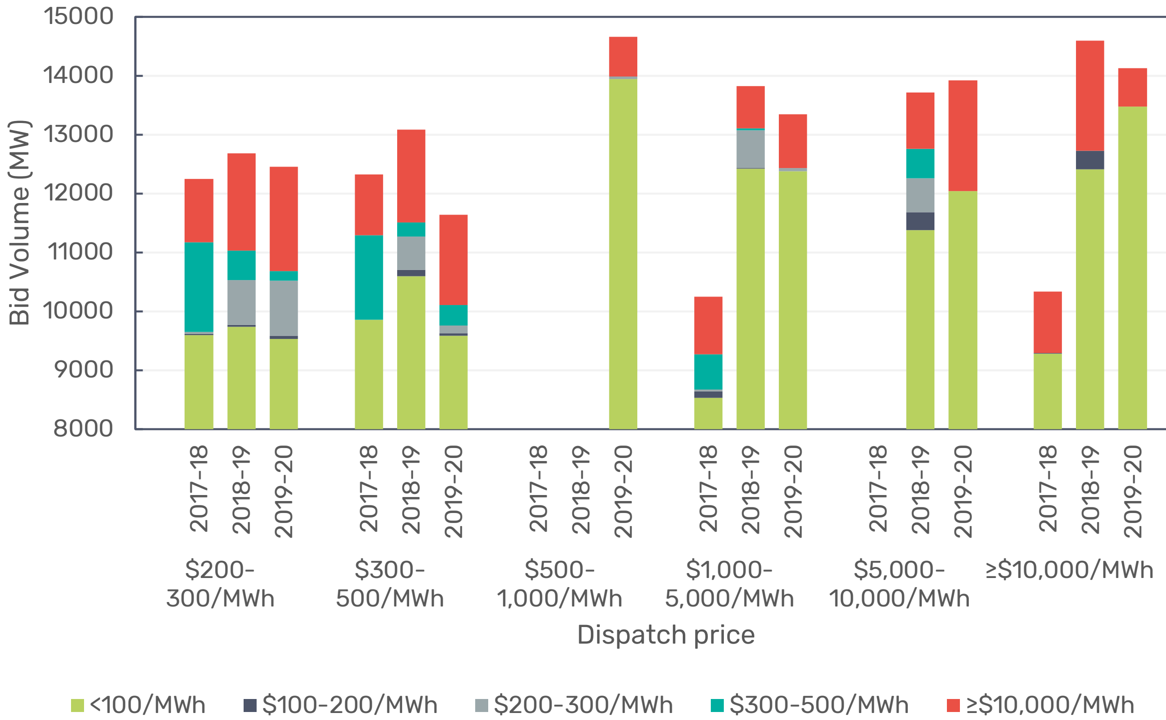



Figure 31: Median volume offered by NSW generators when the dispatch price is greater than or equal to $200/MWh.

## 7.2 Victoria

(a) Victoria had the second steepest bid stack over the past three financial years. A median volume of 0 MW (or very close to 0) was offered between $500-5000/MWh whenever the dispatch price cleared at ≥$200/MWh. Similar to NSW, this gap in the bid stack creates opportunities for demand response to undercut bids from generators.

(b) When the dispatch price was ≥$10,000/MWh, a median volume of 0 MW was offered in bid prices $500-10,000/MWh in the last two financial years. In the 2017-18 financial year, only 17 MW was offered from $5,000-10,000/MW.

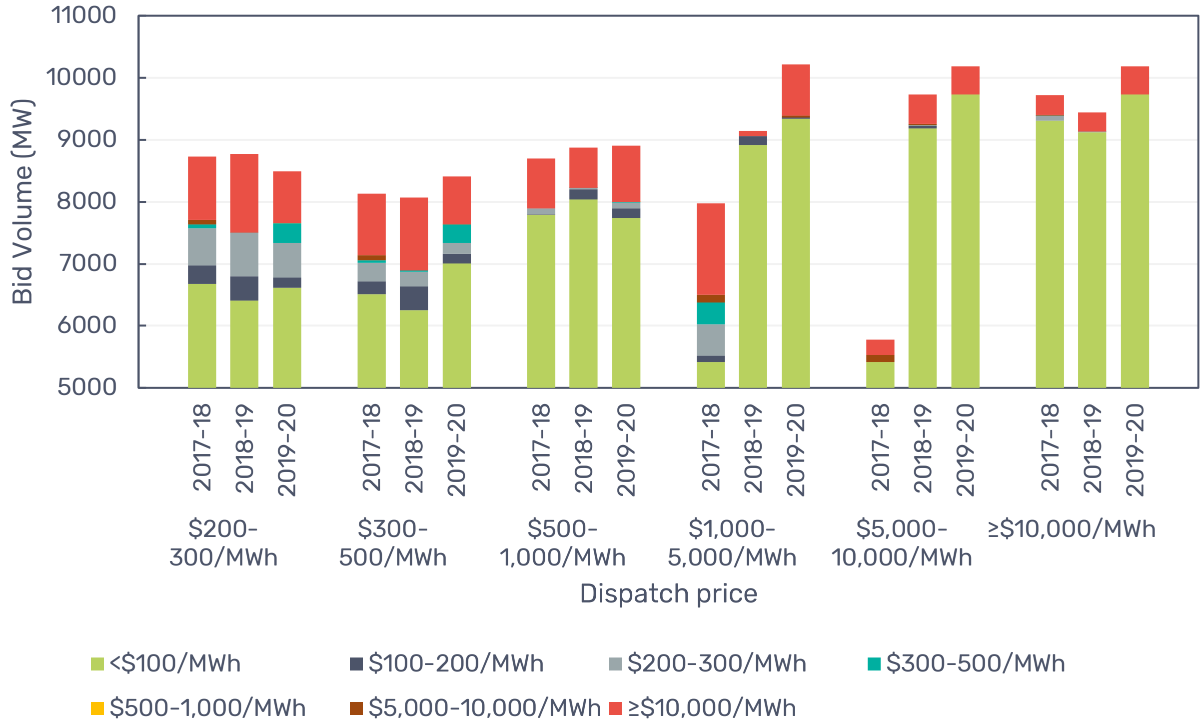



Figure 32: Median volume offered by Victorian generators when the dispatch price is greater than or equal to $200/MWh.

## 7.3 South Australia

(a) In contrast to NSW and Victoria, South Australia tends to have more mid-level bids, but this is still relatively minor. For example, when the dispatch price was $500-1,000/MWh, median volumes offered in the corresponding $500-1000/MWh bid band ranged from 20 to 59 MW (depending on the financial year). This still presents a strong opportunity for a modest amount of additional demand response to impact price outcomes.

(b) Similar to other regions, mid-level bids tend to disappear as the dispatch price gets higher. When the dispatch price was ≥$10,000/MWh, little to no volume was offered between $500-10,000/MWh.

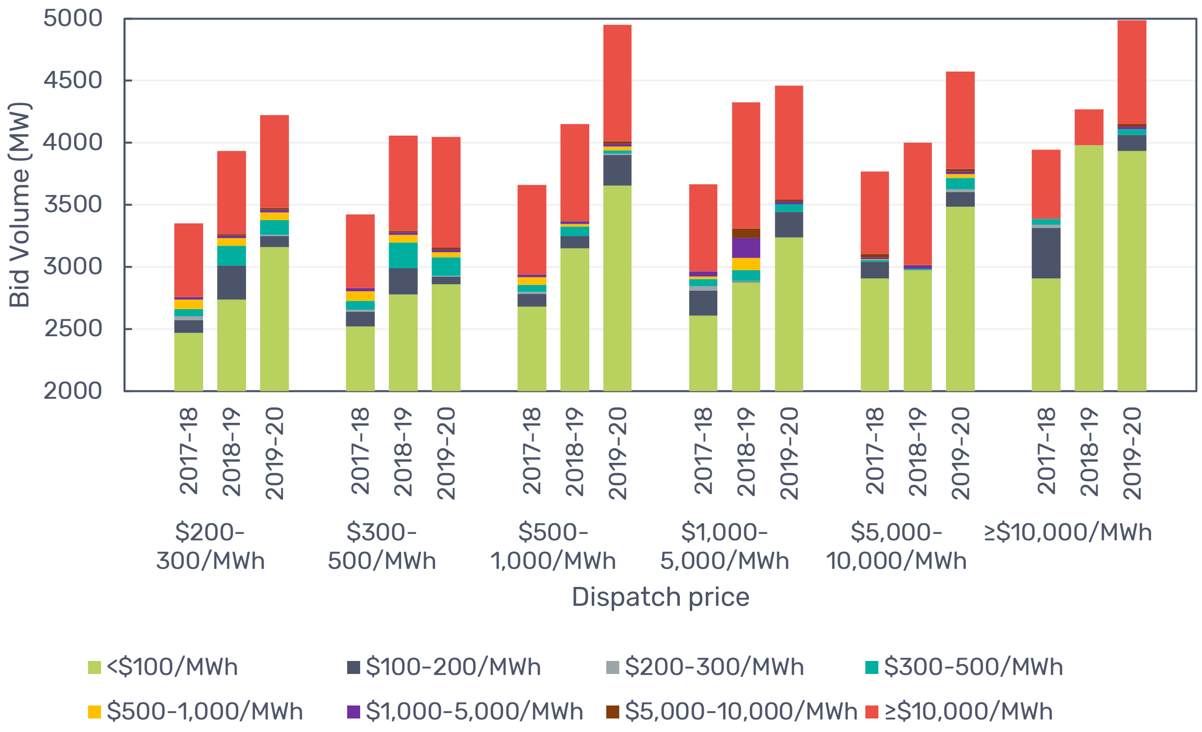
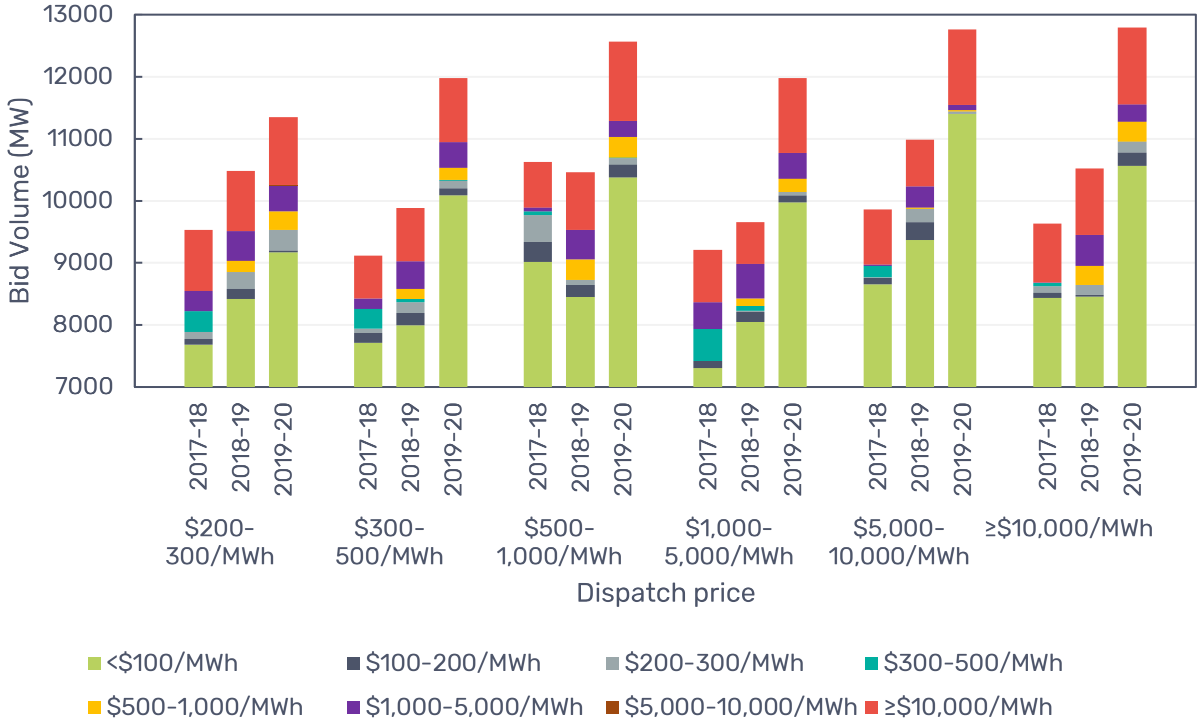



Figure 33: Median volume offered by South Australian generators when the dispatch price is greater than or equal to $200/MWh.

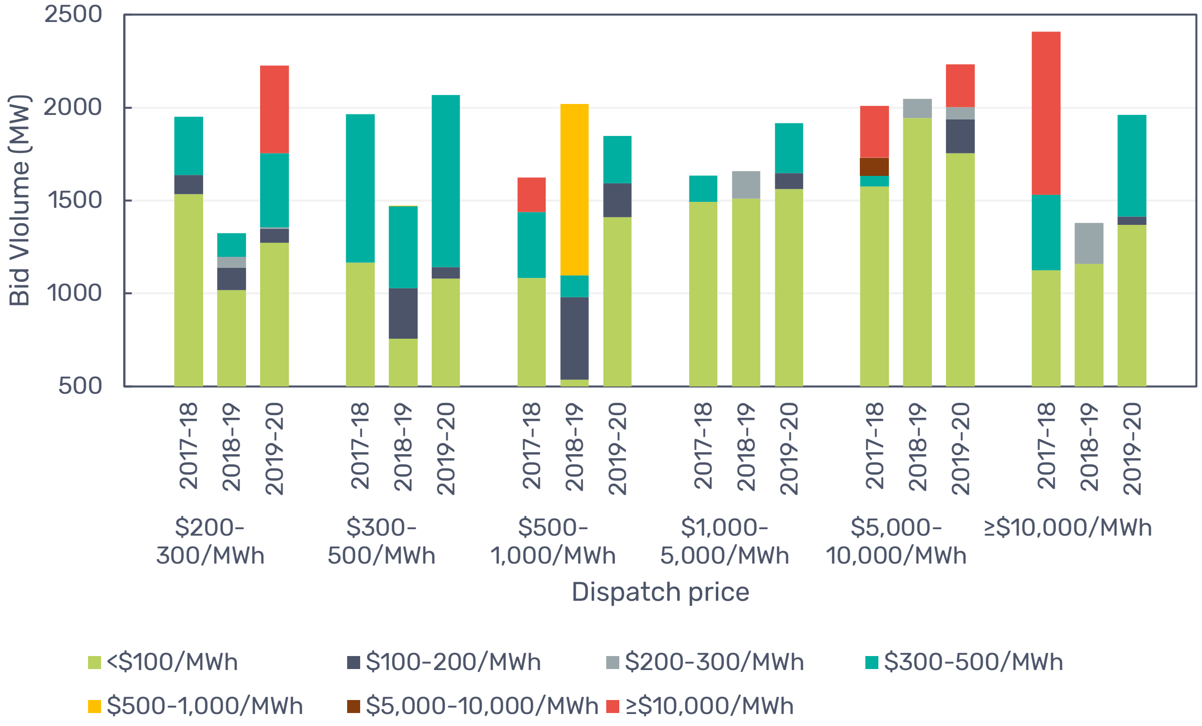
## 7.4 Queensland

(a) Queensland had the flattest bid stack in the NEM, with much higher volumes being offered at mid-levels compared with other regions. Due to this flatter bid stack, demand response would likely be most effective in suppressing prices when the price is ≥$5,000/MWh (due to lower volumes offered at these high levels).



## 7.5 Tasmania

(a) Compared with other regions, Tasmanian generators tended to submit less high price bids. Hence, when prices were above $1,000/MWh, they were often likely to be set by interstate generators.




## 7.6 Note on data cleaning

Sometimes generators submit bids, which are not reflective of what the asset can physically deliver. We have attempted to correct for some of these errors by using the following approach:

(a) When solar farms bid a volume greater than 0 MW between 8pm and 5am, these bids have been excluded.

(b) The total bid volume of individual generators at each five minute dispatch interval has been checked against the maximum availability of the generators and was capped at the maximum availability.

# 8 References

[1] Australian Energy Market Operator, "Demand Side Participation Information Guidelines," December 2020. [Online]. Available: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/dspi/demand-side-participation-information-guidelines-dec-20.pdf?la=en.

[2] Australian Energy Market Operator, "2020 Electricity Statement of Opportunities," August 2020. [Online]. Available: https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2020/2020-electricity-statement-of-opportunities.pdf?la=en.

[3] Australian Energy Market Operator, "Guide To Demand Side Participation Information Portal," 18 March 2020. [Online]. Available: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/dsp/guide-to-demand-side-participation-information-portal.pdf?la=en.

[4] Intelligent Automation, "Home Energy Management System - Save on Electricity Bills," 17 June 2020. [Online]. Available: https://gswitch.com.au/.

[5] Enel X, "Virtual Power Plant a natural fit for Echuca Regional Health," [Online]. Available: https://www.enelx.com/au/en/resources/virtual-power-plant-a-natural-fit-for-echuca-regional-health. [Accessed 10 October 2020].

[6] Tomago Aluminium Company, "About Aluminium - Tomago," 2015. [Online]. Available: https://www.tomago.com.au/about-us/about-aluminium.

[7] Australian Energy Market Operator, "AEMO NEMWEB DATA," 2020. [Online]. Available: https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/market-data-nemweb#mms-data-model.

[8] Australian Energy Market Operator, "Guide to Demand Side Participation CSV Files," 18 March 2020. [Online]. Available: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/dsp/guide-to-demand-side-participation-csv-files.pdf?la=en.

# 9 Appendix: Questionnaire template

## Demand response availability in the NEM

Energy Synapse has been engaged to help the AEMC quantify the demand side flexibility that exists in the National Electricity Market. This work will feed into the design considerations for a two-sided market and potentially an ahead market as well.

We appreciate you sharing your experience to help us map the key characteristics of flexible loads across various sectors.

This questionnaire will close on **Friday 18 September 2020** at **5pm (AEST)**.

If you need further clarification on any of the questions, please contact Marija Petkovic via marija.petkovic@energysynapse.com.au

1. Enter your company name*

2. What customer segments are in your demand response portfolio? (Check all that apply, for any type of demand response)*

☐ Residential

☐ Commercial

☐ Industrial

## 9.1 Residential load flexibility

*Skip this section if you do not have a residential demand response portfolio*

3. What residential loads do you control? (select all that apply)*

☐ Hot water

☐ HVAC (other than hot water)

☐ Embedded generation

☐ Pool pumps

☐ Battery storage

☐ Electric vehicles

☐ No direct control (consumer takes their own actions to alter demand)

☐ Other (please specify)

4. What percentage of your residential demand response portfolio is directly controlled by the retailer or aggregator? (as opposed to the consumer taking their own actions to alter demand)*

5. What is the maximum annual demand of your residential load portfolio? (please include both flexible and inflexible loads) (answer in MW)*

| | |
|---|---|
| QLD | |
| NSW & ACT | |
| VIC | |
| SA | |
| TAS | |

6. What is the maximum aggregated residential load you have reduced or injected into the grid at any one time in the last three years? (for any type of demand response) (answer in MW)*

| | |
|---|---|
| QLD | |
| NSW & ACT | |
| VIC | |
| SA | |
| TAS | |

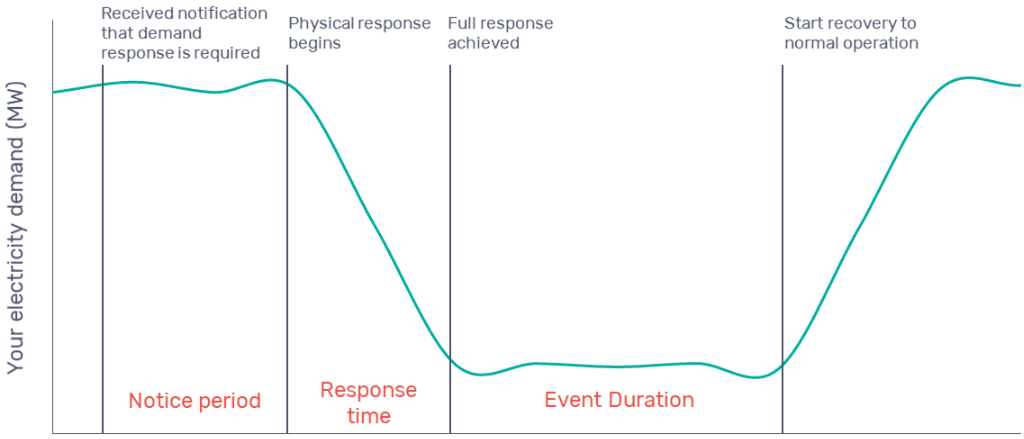
7. When thinking about the potential flexibility that could be available in your total residential load portfolio, what percentage do you think your answer in the previous question represents?*

- ☐ <5%
- ☐ 5 - 15%
- ☐ 15 - 30%
- ☐ 30 - 50%
- ☐ 50 - 70%
- ☐ 70 - 85%
- ☐ 85% or more

8. To be able to utilise your residential demand response portfolio most effectively in the wholesale energy market, what is the average notice period you would require?*

   (Notice period is the time from receiving a notification that demand response is required to starting the load reduction/injection)

**Example: demand response characteristics**




ENERGY SYNAPSE

- ☐ None/can begin response almost immediately
- ☐ Less than 5 minutes
- ☐ 5 - 15 minutes
- ☐ 15 - 30 minutes
- ☐ 30 minutes to 1 hour
- ☐ 1 - 2 hours
- ☐ 2 - 4 hours
- ☐ 4 - 8 hours
- ☐ 1 day
- ☐ 2 day
- ☐ More than 2 days

9. What is the average response time for your residential demand response portfolio? (Response time is the time it takes to physically reduce or inject load)*

- ☐ Less than 1 minute
- ☐ 1 - 5 minutes
- ☐ 5 - 15 minutes
- ☐ 15 - 30 minutes
- ☐ 30 minutes to 1 hour
- ☐ 1 - 2 hours
- ☐ More than 2 hours

10. Once your residential demand response portfolio is activated, how long would you be able to maintain the full response, on average?*

    (This is the "event duration" in the explanatory chart)

- ☐ 5 minutes
- ☐ 5 - 15 minutes
- ☐ 15 - 30 minutes
- ☐ 30 minutes to 1 hour
- ☐ 1 - 2 hours
- ☐ 2 - 4 hours
- ☐ 4 - 6 hours
- ☐ More than 6 hours

11. In terms of physical availability, how often could your residential demand response portfolio be activated?*

- ☐ Several times a day
- ☐ Once a day
- ☐ A few times a week
- ☐ A few times a month
- ☐ A few times a year

12. Does the responsiveness of your residential portfolio vary (either in terms of MW available or notice/response times) according to the time of day, week, or year?*

- ☐ No
- ☐ Yes (please provide further detail)

13. Rank your biggest barriers in using residential demand response to respond to wholesale energy prices (1 = biggest barrier)*

| | |
|---|---|
| Choose an item. | Financial payment not attractive enough/lack of market opportunity |
| Choose an item. | Not being certain of the spot price you will receive |
| Choose an item. | Issues with notice periods (e.g. requiring longer notice periods than are practical under current rules) |
| Choose an item. | Aggregators not being able to provide demand response directly to the wholesale energy market |
| Choose an item. | Technology costs |
| Choose an item. | Engaging with customers and getting them interested in demand response |
| Choose an item. | Time/effort of managing residential demand response program |
| Choose an item. | Other |

14. If you have answered “other” in the previous question, please provide further detail on the barriers you face.

15. At what price point in the wholesale energy market would you consider reducing load in your residential demand response portfolio? (We understand trigger prices may change according to market conditions and customer preferences, but it would be helpful to understand, on average, when a load reduction would be a considered)

- ☐ >$200/MWh
- ☐ >$300/MWh
- ☐ >$500/MWh
- ☐ >$1,000/MWh
- ☐ >$5,000/MWh
- ☐ >$10,000/MWh

16. How do you see the characteristics of your residential demand response portfolio evolving over the next five years?*

17. Are there any other comments you would like to make in relation to your experience with residential demand response?

You can also use this section to clarify your response to any earlier questions.

18. Energy Synapse will be engaging with selected retailers and aggregators to understand their residential load flexibility and business considerations in more detail, which would then be used as a case study. Are you interested in being involved in this?*

- ☐ Yes
- ☐ No

## 9.2 Commercial load flexibility

*Skip this section if you do not have a commercial demand response portfolio*

19. What commercial loads do you control? (select all that apply)*

- ☐ Hot water
- ☐ HVAC (other than hot water)
- ☐ Embedded generation
- ☐ Pool pumps
- ☐ Battery storage
- ☐ Electric vehicles
- ☐ No direct control (energy user takes their own actions to alter demand)
- ☐ Other (please specify)

20. What percentage of your commercial demand response portfolio is directly controlled by the retailer or aggregator? (as opposed to the energy user taking their own actions to alter demand)*

21. What is the maximum annual demand of your commercial load portfolio? (please include both flexible and inflexible loads) (answer in MW)*

| | |
|---|---|
| QLD | |
| NSW & ACT | |
| VIC | |
| SA | |
| TAS | |

22. What is the maximum aggregated commercial load you have reduced or injected into the grid at any one time in the last three years? (for any type of demand response) (answer in MW)*

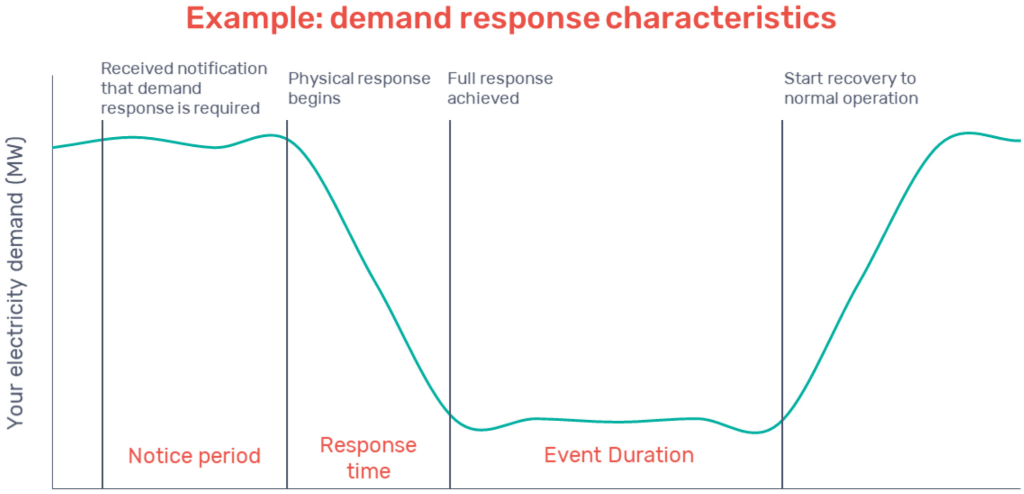
| | |
|---|---|
| QLD | |
| NSW & ACT | |
| VIC | |
| SA | |
| TAS | |

23. When thinking about the potential flexibility that could be available in your total commercial load portfolio, what percentage do you think your answer in the previous question represents?

- ☐ <5%
- ☐ 5 - 15%
- ☐ 15 - 30%
- ☐ 30 - 50%
- ☐ 50 - 70%
- ☐ 70 - 85%
- ☐ 85% or more

24. To be able to utilise your commercial demand response portfolio most effectively in the wholesale energy market, what is the average notice period you would require?*

(Notice period is the time from receiving a notification that demand response is required to starting the load reduction/injection. See example in chart)




ENERGY SYNAPSE

☐ None/can begin response almost immediately

☐ Less than 5 minutes

☐ 5 - 15 minutes

☐ 15 - 30 minutes

☐ 30 minutes to 1 hour

☐ 1 - 2 hours

☐ 2 - 4 hours

☐ 4 - 8 hours

☐ 1 day

☐ 2 day

☐ More than 2 days

25. What is the average response time for your commercial demand response portfolio? (Response time is the time it takes to physically reduce or inject load)*

- ☐ Less than 1 minute
- ☐ 1 - 5 minutes
- ☐ 5 - 15 minutes
- ☐ 15 - 30 minutes
- ☐ 30 minutes to 1 hour
- ☐ 1 - 2 hours
- ☐ More than 2 hours

26. Once your commercial demand response portfolio is activated, how long would you be able to maintain the full response, on average? *

(This is the "event duration" in the explanatory chart)

- ☐ 5 minutes
- ☐ 5 - 15 minutes
- ☐ 15 - 30 minutes
- ☐ 30 minutes to 1 hour
- ☐ 1 - 2 hours
- ☐ 2 - 4 hours
- ☐ 4 - 6 hours
- ☐ More than 6 hours

27. In terms of physical availability, how often could your commercial demand response portfolio be activated? *

- ☐ Several times a day
- ☐ Once a day
- ☐ A few times a week
- ☐ A few times a month
- ☐ A few times a year

28. Does the responsiveness of your commercial portfolio vary (either in terms of MW available or notice/response times) according to times of the day, week, or year? *

☐ No

☐ Yes (please provide further details)

29. Rank your biggest barriers in using commercial demand response to respond to wholesale energy prices (1 = biggest barrier) *

| | |
|---|---|
| Choose an item. | Financial payment not attractive enough/lack of market opportunity |
| Choose an item. | Not being certain of the spot price you will receive |
| Choose an item. | Issues with notice periods (e.g. requiring longer notice periods than are practical under current rules) |
| Choose an item. | Aggregators not being able to provide demand response directly to the wholesale energy market |
| Choose an item. | Technology costs |
| Choose an item. | Engaging with customers and getting them interested in demand response |
| Choose an item. | Time/effort of managing residential demand response program |
| Choose an item. | Other |

30. If you have answered "other" in the previous question, please provide further detail on the barriers you face.

31. At what price point in the wholesale energy market would you consider reducing load in your commercial demand response portfolio? (We understand trigger prices may change according to market conditions and customer preferences, but it would be helpful to understand, on average, when a load reduction would be a considered)

- ☐ >$200/MWh
- ☐ >$300/MWh
- ☐ >$500/MWh
- ☐ >$1,000/MWh
- ☐ >$5,000/MWh
- ☐ >$10,000/MWh

32. How do you see the characteristics of your commercial demand response portfolio evolving over the next five years? *

| |
|---|
| |

33. Are there any other comments you would like to make in relation to your experience with commercial demand response?

You can also use this section to clarify your response to any earlier questions.

| |
|---|
| |

34. Energy Synapse will be engaging with selected retailers and aggregators to understand their residential load flexibility and business considerations in more detail, which would then be used as a case study. Are you interested in being involved in this? *

- ☐ Yes
- ☐ No

## 9.3 Industrial load flexibility

*Skip this section if you do not have an industrial demand response portfolio*

35. In what sectors are the industrial loads that are in your demand response portfolio? (select all that apply)*

- ☐ Aluminium smelting
- ☐ Steel production
- ☐ Chemicals
- ☐ Food and beverage
- ☐ Mining
- ☐ Textiles
- ☐ Pulp and paper
- ☐ Industrial equipment
- ☐ Building products
- ☐ Other (please specify)

36. How do you achieve a load reduction (or injection)?*

- ☐ By interrupting (or ramping up/down) the industrial process
- ☐ By utilising on-site generation and/or energy storage system
- ☐ Combination of both of the above

37. What percentage of your industrial demand response portfolio is directly controlled by the retailer or aggregator? (as opposed to the energy user taking their own actions to alter demand) *

38. What is the maximum annual demand of your industrial load portfolio? (please include both flexible and inflexible loads) (answer in MW)*

| | |
|---|---|
| QLD | |
| NSW & ACT | |
| VIC | |
| SA | |
| TAS | |

39. What is the maximum aggregated industrial load you have reduced or injected into the grid at any one time in the last three years? (for any type of demand response) (answer in MW) *

| | |
|---|---|
| QLD | |
| NSW & ACT | |
| VIC | |
| SA | |
| TAS | |

40. When thinking about the potential flexibility that could be available in your total industrial load portfolio, what percentage do you think your answer in the previous question represents?*

- ☐ <5%
- ☐ 5 - 15%
- ☐ 15 - 30%
- ☐ 30 - 50%
- ☐ 50 - 70%
- ☐ 70 - 85%
- ☐ 85% or more

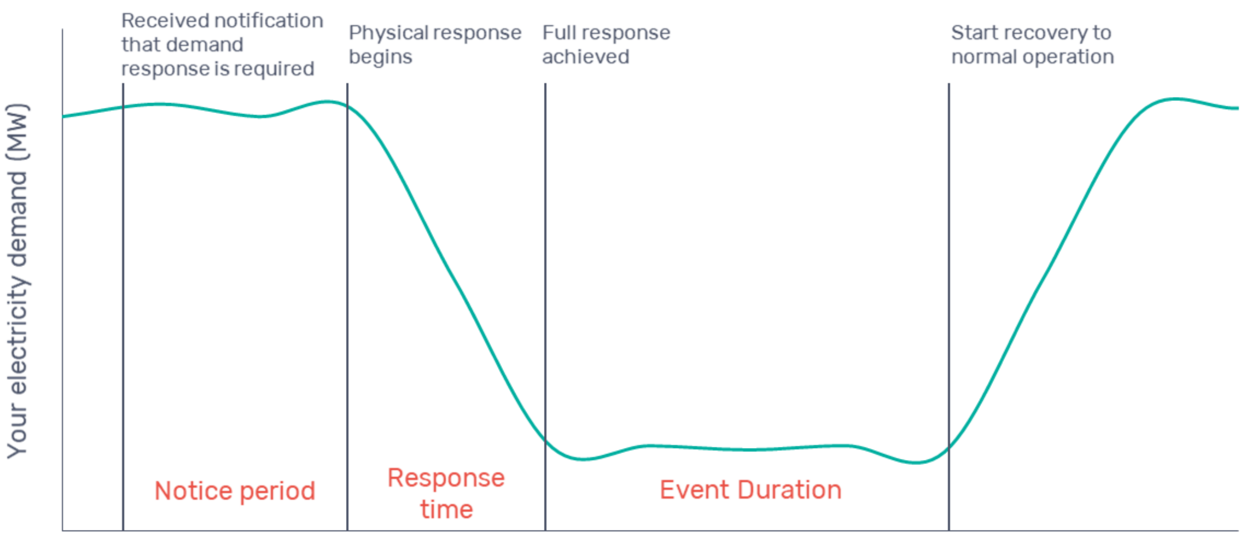
41. To be able to utilise your industrial demand response portfolio most effectively in the wholesale energy market, what notice period would you require?*

Notice period is the time from receiving a notification that demand response is required to starting the load reduction/injection (see example in chart).

Different industrial processes may require different notice periods. Please allocate a percentage value to each notice period below, based on the MW size of your industrial demand response portfolio.

For example, if 10% of your industrial demand response portfolio requires no notice period, you would enter "10%" in the first box.

Example: demand response characteristics




ENERGY SYNAPSE

| | |
|---|---|
| None/can begin response almost immediately | |
| Less than 5 minutes | |
| 5 - 15 minutes | |
| 15 - 30 minutes | |
| 30 minutes - 1 hour | |
| 1 - 2 hours | |
| 2 - 4 hours | |
| 4 - 8 hours | |
| 1 day | |
| 2 days | |
| More than 2 days | |

42. Response time is the time it takes to physically reduce or inject load. Response time can vary across different industrial processes.

    Please allocate a percentage value (as a total of your industrial demand response portfolio) for each response time listed below. *

| | |
|---|---|
| Less than 1 minute | |
| 1 - 5 minutes | |
| 5 - 15 minutes | |
| 15 - 30 minutes | |
| 30 minutes - 1 hour | |
| 1 - 2 hours | |
| More than 2 hours | |

43. Once your industrial demand response portfolio is activated, how long would you be able to maintain the full response? *

    (This is the "event duration" in the explanatory chart)

    Please allocate a percentage value based on the MW size of your industrial demand response portfolio.

    For example, if 20% of your industrial demand response portfolio could be activated for 1-2 hours, you would enter "20%" in the 1-2 hour box.

| | |
|---|---|
| 5 minutes | |
| 5 - 15 minutes | |
| 15 - 30 minutes | |
| 30 minutes - 1 hour | |
| 1 - 2 hours | |
| 2 – 4 hours | |
| 4 – 6 hours | |
| More than 6 hours | |

44. In terms of physical availability, how often could your industrial demand response portfolio be activated? *

Please allocate a percentage value for each box below. For example, if 10% of your industrial demand response portfolio can be activated several times per day, you would enter "10%" in the first box.

| | |
|---|---|
| Several times a day | |
| Once a day | |
| A few times a week | |
| A few times a month | |
| A few times a year | |

45. Does the responsiveness of your industrial portfolio vary (either in terms of MW available or notice/response times) according to different times of the day, week, or year? *

- ☐ No
- ☐ Yes (please provide further detail)

46. Rank your biggest barriers in using industrial demand response to respond to wholesale energy prices (1 = biggest barrier) *

| | |
|---|---|
| Choose an item. | Financial payment not attractive enough/lack of market opportunity |
| Choose an item. | Not being certain of the spot price you will receive |
| Choose an item. | Issues with notice periods (e.g. requiring longer notice periods than are practical under current rules) |
| Choose an item. | Aggregators not being able to provide demand response directly to the wholesale energy market |
| Choose an item. | Technology costs |
| Choose an item. | Engaging with customers and getting them interested in demand response |
| Choose an item. | Time/effort of managing residential demand response program |
| Choose an item. | Other |

47. If you answered "other" in the previous question, please provide further details on the barriers you face.

48. At what price point in the wholesale energy market would you consider reducing load in your industrial demand response portfolio? (We understand trigger prices may change according to market conditions and customer preferences, but it would be helpful to understand, on average, when a load reduction would be a considered)

☐ >$200/MWh

☐ >$300/MWh

☐ >$500/MWh

☐ >$1,000/MWh

☐ >$5,000/MWh

☐ >$10,000/MWh

49. How do you see the characteristics of your industrial demand response portfolio evolving over next five years? *

50. Are there any other comments you would like to make in relation to your experience with industrial demand response?

You can also use this section to clarify your response to any earlier questions.