AGL NSW Demand Response

Final ARENA Knowledge Sharing Report

May 2021

Table of Contents

This Project received funding from ARENA as part of ARENA's Advancing Renewables Programme - Demand Response and from the New South Wales Government.

1. Executive Summary

This is the final knowledge sharing report for the three-year NSW Demand Response Project conducted by AGL and co-funded by ARENA and the NSW Government.

The trial comprised up to 8,000 customers in a residential behavioural demand response program, a small-scale trial of residential controlled load demand response focussing on air conditioners and electric vehicle charging, and up to 20MW of commercial and industrial demand response for the Australian Energy Market Operator's (AEMO's) Reliability and Emergency Reserve Trader (RERT) program.

The trial successfully demonstrated the use of demand response (DR) as an effective source of reserve capacity in the National Electricity Market. The key findings from each of the trial streams were:

Residential Behavioural Demand Response

- The behavioural program demonstrated a net reduction in demand of up to 3.9MW.
- Customers were highly engaged by the program.
- Measuring energy that isn't used (via a baseline) can lead to variable results that may be difficult to explain to customers.
- Fluctuations in rooftop solar output may swamp customer's demand response efforts.
- The low penetration of smart meters, and challenges upgrading to smart meters, present a barrier to the implementation of residential DR programs in NSW.

Residential Controlled Load Demand Response

- Complexity, high costs and erratic outcomes from controlling already installed air conditioners using the mechanism specified in Australian Standard AS4755 make this approach unviable.
- Electric vehicle charging has the potential to be a substantial controllable load that can be shaped and managed without adversely affecting vehicle amenity.

Commercial and Industrial Demand Response

- 20MW of demand response was successfully dispatched into AEMO's RERT program.
- The current AEMO RERT baseline disqualifies many types of commercial and industrial (C&I) loads participating in, or being adequately rewarded for, demand response, and can present a challenge operating a C&I DR portfolio.
- C&I DR portfolios need to be significantly over-contracted to provide a consistent response over time.
- Critical services loads may not be available for DR during emergency conditions.

2. Introduction

This is the final knowledge sharing report for the NSW Demand Response Project conducted by AGL. This activity received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Programme – Demand Response, and from the NSW Government.

This report covers the entire period of the project, which commenced in October 2017.

The AGL NSW Demand Response Project comprised the following elements:

- A trial of residential behavioural demand response over three years, comprising up to 8,000 customers in the third year of the program.
- A small-scale trial of residential controlled load demand response, focussing on the control of residential air conditioners and electric vehicle charging.
- A trial of commercial and industrial demand response over three years, providing up to 20MW for AEMO's RERT program.

The activities undertaken and the lessons learnt in these three trial streams are detailed in this report.

AGL would like to thank ARENA and the NSW Government for the opportunity to participate in this important program. AGL is now undertaking larger scale rollouts of both residential behavioural and commercial and industrial demand response, to a large extent based on the knowledge gained from this project.

3. Project Performance

3.1. Performance vs Outcomes and Objectives

3.1.1. Original ARENA outcomes and competitive round objectives

The objectives for the Activity will be achieved through the following Outcomes:

a) Delivery of Knowledge Sharing in accordance with Knowledge Sharing Plan.

b) Contribution to the following objectives:

(i) Demonstrate that demand response is an effective source of reserve capacity for maintaining reliability of the electricity grid during contingency events and that demand response resources can be rapidly developed for deployment from 1 December 2017.

(ii) Provide an evidence base to inform the merits and design of a new market, or other mechanism, for demand response to assist with grid reliability and security, allowing for greater uptake of renewable energy.

(iii) Improve the commercial and technical readiness of demand response providers and technologies, in particular to help demonstrate and commercialise the use of demand response for grid security and reliability.

3.1.2. Performance

Delivery of Knowledge Sharing in accordance with Knowledge Sharing Plan.

AGL has completed the following public Knowledge Sharing milestone reports, all available at the ARENA project page https://arena.gov.au/projects/agl-demand-response/:

- September 2018
- October 2019
- November 2020

AGL has provided detailed demand response data to ARENA.

AGL participated in all of the Demand Response Knowledge Sharing workshops held during the course of the project.

AGL has participated in all of the requested project interviews with ARENA's consultants for the project, Oakley Greenwood.

AGL has provided the Final Project Report (this report).

Demonstrate that demand response is an effective source of reserve capacity for maintaining reliability of the electricity grid during contingency events and that demand response resources can be rapidly developed for deployment from 1 December 2017.

AGL rapidly contracted 17MW of demand response from 1 December 2017 to meet the contracted requirements for this project. This later increased to 20MW of commercial and industrial demand response plus 3MW of residential demand response.

The demand response provided by this project was demonstrated to be of value through the six-monthly AEMO tests of the commercial and industrial portfolio, through the many test events conducted by AGL on the residential portfolio and through two dispatches by AEMO under the RERT program on 23 January 2020 and 31 January 2020. These tests and events are covered in sections 4.2.4, 4.3.6, 4.4.5, 5.2.4, 5.3.4, 6.8 and 6.9 of this report.

Provide an evidence base to inform the merits and design of a new market, or other mechanism, for demand response to assist with grid reliability and security, allowing for greater uptake of renewable energy.

The evidence collected during the project, and presented in the knowledge sharing reports and other fora, has been utilised in the design of the Wholesale Demand Response Mechanism due to commence operation in October 2021. In particular, the issues surrounding the use of baselines uncovered by this project (covered in section 6.11.1 of this report, and also the subject of discussions between AGL, ARENA and AEMO) have contributed to the design of the Wholesale Demand Response Mechanism, which includes provision for multiple baselines that can be used to suit the different types of load participating in demand response.

Improve the commercial and technical readiness of demand response providers and technologies, in particular to help demonstrate and commercialise the use of demand response for grid security and reliability.

This project has provided the opportunity to test the commercial model for demand response and to trial a number of new technologies, some of which have been successful (refer section 5.3.7), some of which have been partially successful (refer section 4.5.5) and some of which have not been successful (refer sections 5.2.6 and 6.11.3) but nevertheless provide pointers for future development. Based on experience gained during the project, AGL has moved forward with a commercial model for both residential behavioural and industrial and commercial demand response (see sections 4.6 and 6.12).

3.2. Key Lessons Learnt

The key lessons learnt from the project are covered in the following sections of the report:

Residential Behavioural Demand Response	Section 4.5
Residential Controlled Load Demand Response	Section 5.4
Commercial and Industrial Demand Response	Section 6.11

4. Residential Behavioural DR

4.1. Introduction

AGL implemented a residential behavioural demand response program, known as “Peak Energy Rewards”, for the three years of the project. As this was a trial, AGL modified the operation of the program in years two and three based on what had been learnt the previous year.

Due to the experimental nature of the program, the lead-time required to trigger events, the relatively low MW demand reduction and the low likelihood of real AEMO RERT events during the trial period, the events for this cohort were tests triggered by AGL rather than actual AEMO RERT events. This allowed the collection of considerably more event data than would have been possible otherwise.

4.2. Year 1

The first year of the program (2017/18) comprised 750 customers who received SMS messages as event alerts and post-event emails showing their results.

Customers were incentivised by payments for signing up for the program, together with payments based upon their kWh load reduction during an event.

4.2.1. Customer recruitment

The program targeted AGL’s residential customer base in New South Wales across all metropolitan and regional areas, including pensioners and healthcare card holders. Customers were required to have an existing smart meter to enable the demand response to be measured. Customers flagged for life support or bad debt were excluded from the recruitment campaign.

The recruitment campaign consisted of a targeted email linked to the campaign landing page with a registration form. Eligibility checks ensured customers were based in NSW with a smart meter and customers were onboarded to the program with a welcome email and welcome pack outlining program details and expectations. Customers were offered an incentive structure comprising $50 to sign up, and an event reward of $2 for each kWh reduced calculated from the customer’s baseline energy use.

AGL had a strong response to the recruitment. Given the upfront reward of $50, which was designed to encourage recruitment, the conversion was higher than average for similar trials.

Customers were asked to participate in four two-hour events on 19 January, 14 February, 19 March and 13 April 2018. In the absence of AEMO triggered events, these events were initiated by AGL to maintain customer engagement with the program. Participation in the events was positive with more than 60% of customers reducing their energy usage.

Between 11% and 15% of customers responded to the post-event survey. From this cohort, more than 90% said they were either likely, or very likely, to participate in a future event.

4.2.2. Communication

Previous research has shown that our customers prefer to communicate by digital channels and, as such, we have used email and SMS extensively through the program.

For information sharing such as recruitment, on-boarding and performance summaries, customers have been happy with email, particularly for the post event summaries showing their performance during the event and their reward. This has been evidenced through strong engagement in post-event surveys and customer interactions by email as they queried their relative reductions.

Event alerts were delivered via SMS, which proved successful for advising the existence and timing of events. The event communication process was:

- A SMS 24 hours before the event
- A reminder SMS message 15 – 30 minutes before the event start, with a link to an AGL website for energy reduction tips
- A final SMS message immediately after the event, thanking the customer and with a link for a quick post event survey (which asks about participation, actions and comfort)
- An email 2 – 7 days after the event with the performance outcome (calculated using AGL's baseline methodology), confirmation of the dollar reward for the event and accumulated rewards for all events to-date.

Customers could opt-in or opt-out of events by their actions and didn't need to inform AGL of their decision (although they could self-report in the after-event survey).

One issue identified with SMSs was that the program participant, account owner and SMS recipient were not always the same person, leading to the possibility that the SMS went to someone who was unable to act upon it at the time.

4.2.3. Customer segments

Over time it became apparent that the trial cohort was skewed towards more progressive and engaged energy users, with many customers already motivated to use less energy.

Approximately 50% of the summer 2017/18 cohort already had a solar system installed. Since only smart meter customers were eligible for the program, this cohort is naturally skewed towards solar system owners (who must install a smart meter to access feed-in tariffs), however solar system owners were still over-represented in the trial cohort over and above the underlying level of solar ownership in the NSW smart meter customer population.

4.2.4. Event results

AGL triggered four Peak Events from January to April 2018 on business days when the forecast temperature was high.

From a customer's perspective these were real events (even if they were not AEMO RERT events) and the customers were rewarded financially for their actions. AGL chose two hours as the length of the event to bring some significance to the event without overly affecting the customer's comfort. This choice was based on AGL's previous experience with residential customers in the 2016 Demand Response Carrum Downs pilot.

The graph below shows the aggregate response across the four events from the customers in the program.

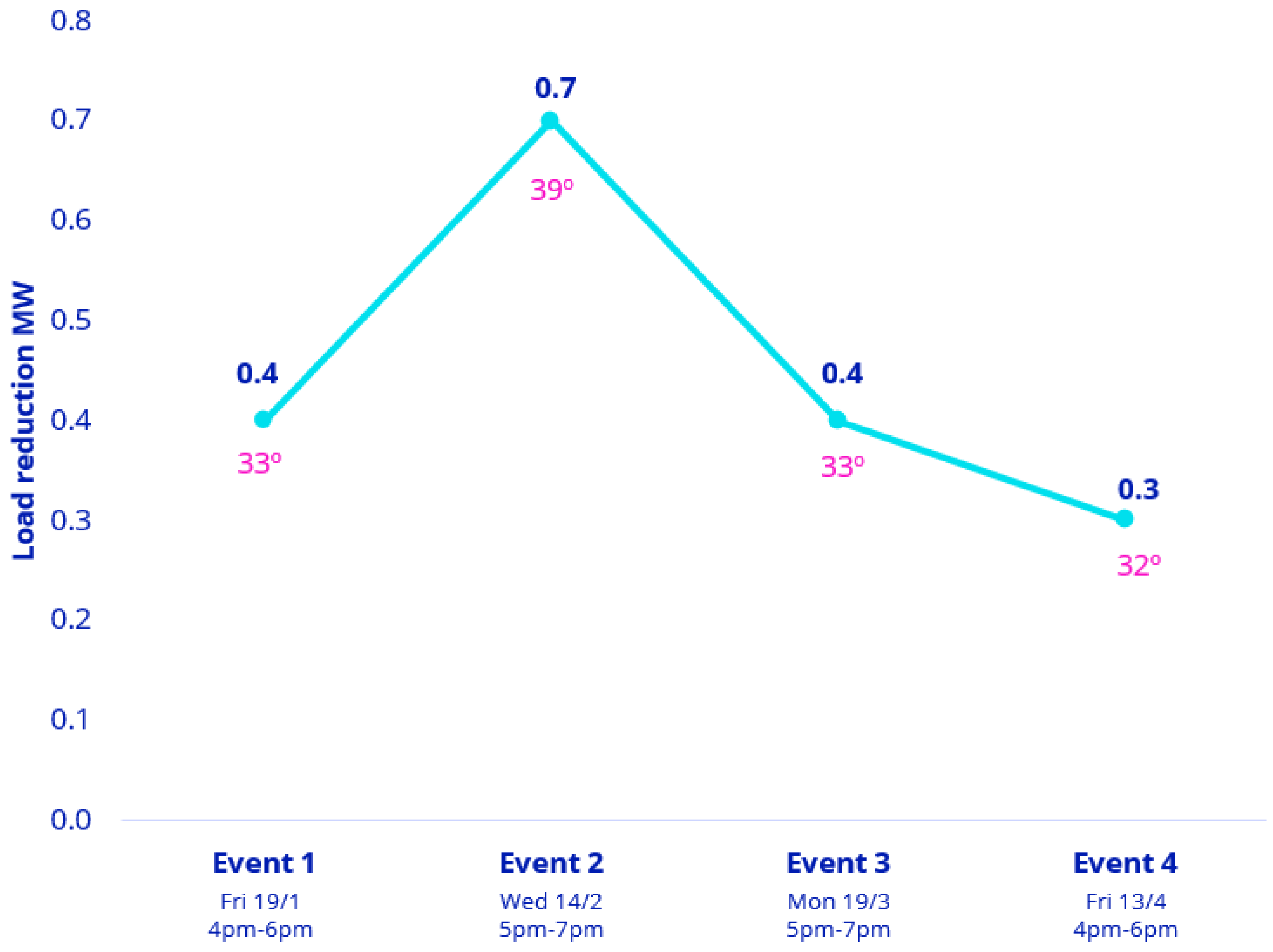

Figure 1 – Aggregate event results for residential behavioural program in Year 1

Insights from the four events suggested[1]:

- Roughly one third of customers reduced consumption a lot, one third reduced a little and one third did not depart noticeably from their expected usage.
- The top 10% of performers were responsible for more than half of the total energy reduction of participating customers.
- The result from the event on a 39°C day was almost double the result from the other event days which were 6° – 7° cooler.
- There was a slight drop in participation from Event 1 to Event 4, suggesting that the “novelty factor” may have worn off towards the end of summer.

4.2.5. Incentives

The average customer incentive across the four events was $12 (customer incentives were rounded up to the nearest whole dollar). The highest performing customer received $93 across the four events, and the top 10% of customers received an average of $43 across the four events. For customers with a high potential for energy reduction, these are not insignificant amounts. Conversely, the bottom 10% of customers received only $2 across the four events, typically from a small energy reduction in only one of the four events.

Program feedback suggested that many customers consider the monetary value of their rewards to be insignificant but explained that this wasn’t their primary motivation for participating. Others explained that “every little bit counts” and even small rewards were valued.

4.2.6. Customer research

Participants expressed very high levels of satisfaction with the program. Approximately 40% of the total program cohort responded to the end-of-summer survey, with the headline results being:

- Understood the incentive calculation (70%)
- Fairness of incentives according to effort (80%)
- Overall satisfaction with the program (85%)
- Would recommend the program to others (90%)

Many explained that the program was simple and easy to participate in, and expressed a desire to continue in the program after the end of the trial. Many saw it as having a low impact on their wellbeing, from both a behavioural change and reward perspective, but were motivated to continue because of its potentially larger impact across the total group of participants.

[1] Note: All results are expressed relative to AGL’s baseline methodology. See Section 4.2.7 for further information on baseline calculations.

There was a discrepancy noted between some customer's perceptions of event participation and the actual results. 40% of end-of-summer survey participants had a measured energy reduction for all four events according to the AGL baseline, however 62% reported that they participated in all four events.

There may be several reasons for this discrepancy. Some customer's perception of "participating" may involve actions that do not have a measurable impact, for example turning off a few lights. In some situations, the baseline methodology may not have detected genuine attempts at energy reductions, or some customers may not have accurately remembered the number of events they participated in by the time the end-of-summer survey was conducted.

4.2.7. Residential baseline

A key challenge of any demand response program is the measurement of how much energy was not used during an event. A baseline estimates the electricity that customers would have consumed if they had not taken any reduction measures.

Under the SN RERT program, AEMO supplies the baseline formula by which the aggregate demand response is measured, however it is up to the aggregator to determine how each individual customer should be incentivised to meet the overall portfolio objectives. For AGL's residential portfolio, we used an in-house baseline methodology to calculate the result for individual customers, developed based on experience from a previous demand response trial in Carrum Downs, Victoria.

The AGL baseline averages the usage at a particular time of the day for days of a similar temperature over the last five weeks (differentiating between weekdays or the weekend) and anchors this to the actual consumption before and after the event. It is calculated using the following steps:

- Generation of a site level forecast based on regression of the previous five weeks net load (load minus solar) excluding any controlled load channels against temperature, time of day and workday/non-workday.
- De-biasing by comparing the previous seven days forecasts against the actuals for the same time of day as the event period and adjusting the event period baseline forecast.
- Anchoring the predicted consumption outside the event period to the actual consumption on that day, based on smoothed consumption either side of the event period.

While AGL's baseline performed very well across the four events, some discrepancies were noted. False positives occurred when the baseline methodology detected a reduction for customers who did not actively change their behaviour, and false negatives occurred when the baseline methodology did not detect a reduction for customers who genuinely changed their behaviour, including customers who deliberately left the house earlier in the day to avoid being home during the event.

A challenge of any baseline methodology is that, under different temperature and household energy use scenarios, different results will be achieved, ie the same behaviour change or action by a participant may produce a different monetary reward from event to event. One example of this, as seen in the aggregate results, is that energy reduction is highly temperature dependant.

4.3. Year 2

Following customer feedback from the first year, Year 2 of the program trialled the provision of individual, near-real-time performance information to participants during events. The intention of this was to test whether the near-real-time information made a significant difference to the DR performance of the portfolio or the customer satisfaction with the program.

The program also moved from a per kWh payment for load reductions to fixed payments for reaching load reduction targets that were set for each individual customer using a deep learning algorithm. The sign-up payment was also removed and replaced with a payment for completing the pre-event surveys.

4.3.1. Recruitment

The customer base for the program was increased from 750 to 3,500 in Year 2, requiring a significantly intensified recruitment process compared to the first year.

Similar to Year 1, recruitment was initiated by an Electronic Direct Mail (EDM) marketing message, with customers were selected to receive the EDM based on the following criteria:

- AGL residential customers in NSW for whom an email address was known and for whom there were no flags in place for do-not-market or life support.
- The customer was in the Peak Energy Rewards program the previous year and had indicated a desire to be included in year two of the program.
- The customer already had a smart meter installed.
- The customer did not have a smart meter installed but lived in a geographic area specified by our Meter Data Provider (MDP) as being suitable for having a meter exchange performed in the timeframe available.

Multiple EDM dispatches were undertaken approximately a week apart, including a re-targeting campaign after a suitable period aimed at customers who had not responded to previous EDMs. The multiple dispatches allowed:

- The response rate to be carefully monitored.
- Re-wording of later EDMs as more experience was gained, which slightly improved the response rate.
- Adjustment of EDM quantity to ensure that the program was not over-subscribed.

The EDM contained a link for customers to register for the program through AGL's "My Account" online services portal.

At the conclusion of the campaign, 4,300 customers had registered. Of these, 2,000 had smart meters and it was necessary to install new smart meters at the remaining 2,300 properties.

There was a large failure rate of smart meter installations, mostly due to access problems and most commonly at apartments and multi-unit dwellings. Around 800 meter installations were not able to proceed because of access or technical issues, with a final total of just over 3,500 participants registered in the program prior to the commencement of summer events.

4.3.2. Customer incentives

Following customer research and testing, the Year 2 program was designed to reward customers with fixed dollar amounts based upon achieving percentage load reduction targets rather than a variable reward calculated from their kWh reduction. The sign-up bonus in Year 1 was replaced with an event-by-event bonus for completing a pre-event survey. The monetary value of this was similar to the sign-up bonus for anyone completing all six pre-event surveys (including the winter event), however it was designed to prompt a greater awareness of, and engagement in, the events themselves.

For each event, customers could receive the following payments:

1) $10 for clicking the link in the SMS and completing the survey (even if the response was that they weren't going to participate in the event).

2) $5 for achieving the first load reduction target.

3) A further $5 for achieving the second load reduction target.

4.3.3. Target setting

The two target levels were set on a per customer basis the day before an event. AGL's data analytics team utilised a "deep learning" methodology to forecast the loads of all of the customers individually. Percentage reduction targets were then applied to the forecast customer loads to calculate personalised load reduction targets for each customer. Target 1 was set at a 15% load reduction for all events, while Target 2 was set at a 30% load reduction for all events except event 4, where it was set at 40% to see if that made any significant difference to performance.

For solar sites, the deep learning algorithm incorporated a model for solar production to attempt to remove the effect of variable solar production from the customer's load forecast, so that the targets were based on reductions in household load only.

4.3.4. Near-real-time data

All DR programs require interval meters, or "smart meters", to be installed at the customer premises to measure the response for each half hour of the DR event. Interval meters in the NEM provide "day after" metering data, however this is not suitable for a program that is aiming to provide real-time feedback to customers during an event.

In order to provide in-event feedback, AGL contracted a MDP to provide an additional meter data stream, separate to that used in the NEM, from each of the meters in the program. This data stream contained five-minute interval data read every fifteen minutes (ie, three readings every fifteen minutes) and can be referred to as "near real time". Whilst not perfect, this provided a reasonable solution for customer feedback during events.

The MDP presented the near real time data streams at an internet Application Program Interface (API), which was interfaced to AGL back-office software developed for the purpose. The data was then presented to customers via a mobile-friendly web portal for display on smart phones.

4.3.5. Communications

As in the previous year, customers were alerted to an upcoming event via two SMS messages, one the day before the event and another an hour before the event. The events were "opt-in", however the customer could opt-in at any stage up to the end of an event, allowing customers to opt-in late if they had forgotten about or not seen the SMS, or to wait until they knew what they were doing on the day before deciding whether to participate.

The first SMS contained a link to a survey in the web portal that asked the customer if they were going to participate in the event and, if so, how they planned to participate. Once the survey was complete, the customer was taken to the event page which showed a graphic of their current usage and the two targets set for them. There were also energy tips in the portal to help customers understand which appliances were likely to be significant contributors to their peak load and what they could do to reduce the impact of these; for example, pre-cool house before turning off the air conditioner, or defer use of major appliances such as washing machines and dryers. All communication with the customer included the advice to prioritise their health.

The second SMS also contained a link which took the customer to either the survey (if they hadn't already completed it) or straight to the event page (if they had).

Once the event had started, customers could either leave the event page active on their phone or revisit it at any time to monitor how they were tracking against the targets. Alternatively, the customer could elect not to look at the page at all; it wasn't necessary to be engaged with the customer portal in order to participate in the event.

Once the event had finished, the final result for each individual customer was calculated and displayed in the web portal within an hour. An SMS was sent to alert customers to this. The portal showed which targets they had achieved and what their financial reward would be.

Rewards were paid by bill credit on the next customer bill issued after the event.

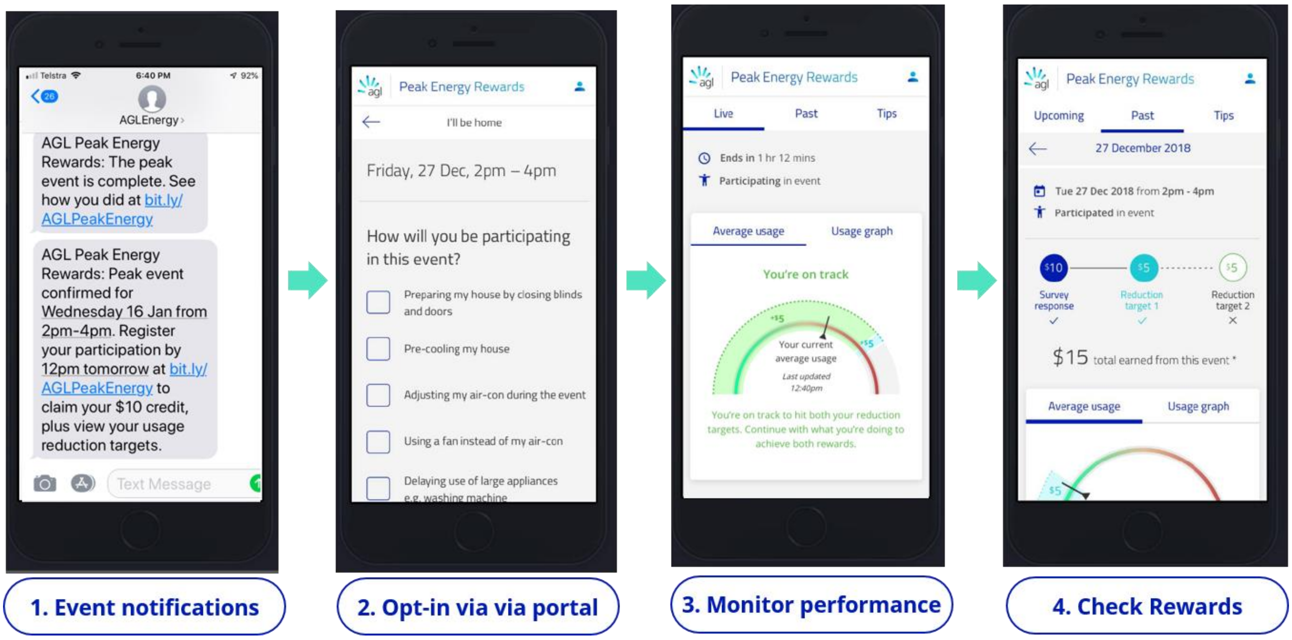

Figure 2 - Customer event experience

4.3.6. Event results

Five two-hour events were conducted between January and March 2019 with a sixth event in late July 2019 to establish portfolio performance during winter.

Events were triggered by AGL on days when the forecast was for generally high temperatures and it was possible that there may have been grid supply issues. As it happened, no supply problems occurred on any of these days, however the total system demand in NSW at the time of the 31 January event was very high.

A significant constraint over event day selection was the preparation time necessary for the deep learning algorithm to calculate the individual load forecasts and target setting, which required a considerable amount of computing power and manual work on the part of the data analytics team. This had to be completed before the first SMS was sent the day before the event, so an event countdown was started 48 hours before the proposed event time.

Targets for all events except event 4 were set at 15% load reduction for target 1 and 30% load reduction for target 2. For event 4, target 2 was set at 40% load reduction.

Whilst the deep learning forecast was used to set customer targets the day prior to the event and to calculate the customer rewards at the end of the event, post-event portfolio performance analysis was performed using the same anchoring baseline method developed by AGL for the Year 1 program. The rationale for this was:

- It allowed a direct comparison between results across the years.

- A baseline calculation carried out after the event day, using real consumption data prior to and after the event, will almost always yield a more accurate baseline than a forecast calculated the day prior to the event.

The following figure shows the overall average load reduction per event for those customers that indicated that they would participate during the pre-event survey, and who actually reduced their load, together with the corresponding maximum temperature on event day. Customers that didn't respond to the survey, responded "no", or increased their load against baseline are not included in the graph. The load reduction is measured against the anchoring baseline used in Year 1 and is the average across the two-hour event.

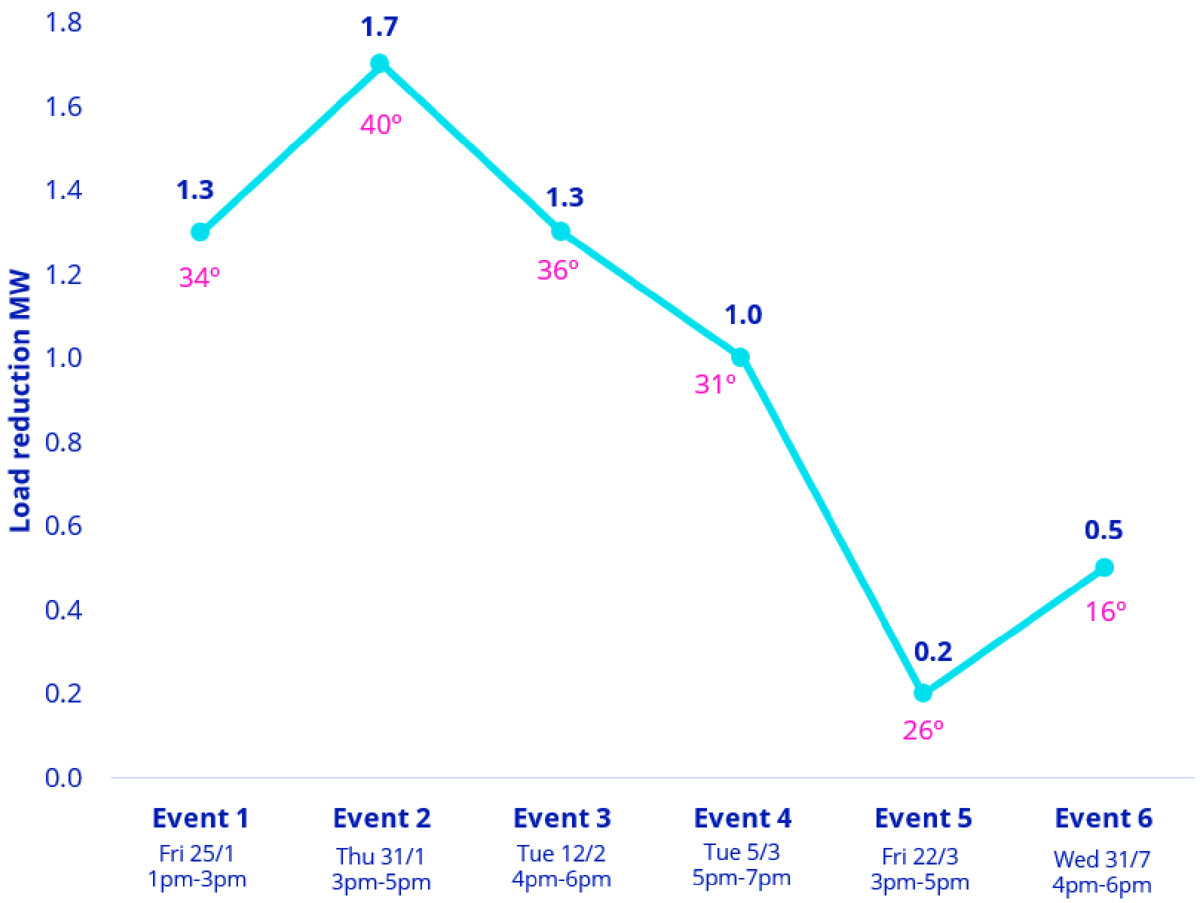

Figure 3 – Aggregate event results for residential behavioural program in Year 2

The first noticeable outcome is that there is a strong correlation between load reduction and temperature. The result for Event 2 (40° day) is more than three times the result for Event 5 (26° day). This, together with the 3:00pm – 5:00pm timing of those events (when cooking loads are unlikely), suggests that the majority of the load being reduced on hot days is air conditioning.

The winter test (Event 6), during quite cold weather for Sydney, shows a stronger load reduction than Event 5 in milder weather, most likely caused by heating loads. Nevertheless, the winter load reduction is not as strong as the reductions during summer.

The percentage of customers registered in the program who participated in the first five events is shown below. Around 60% of registrants actively participated, although the participation rate dropped from 63% at the beginning of the program to 54% at the end. This may also partly explain the lower total load reduction toward the end of the program.

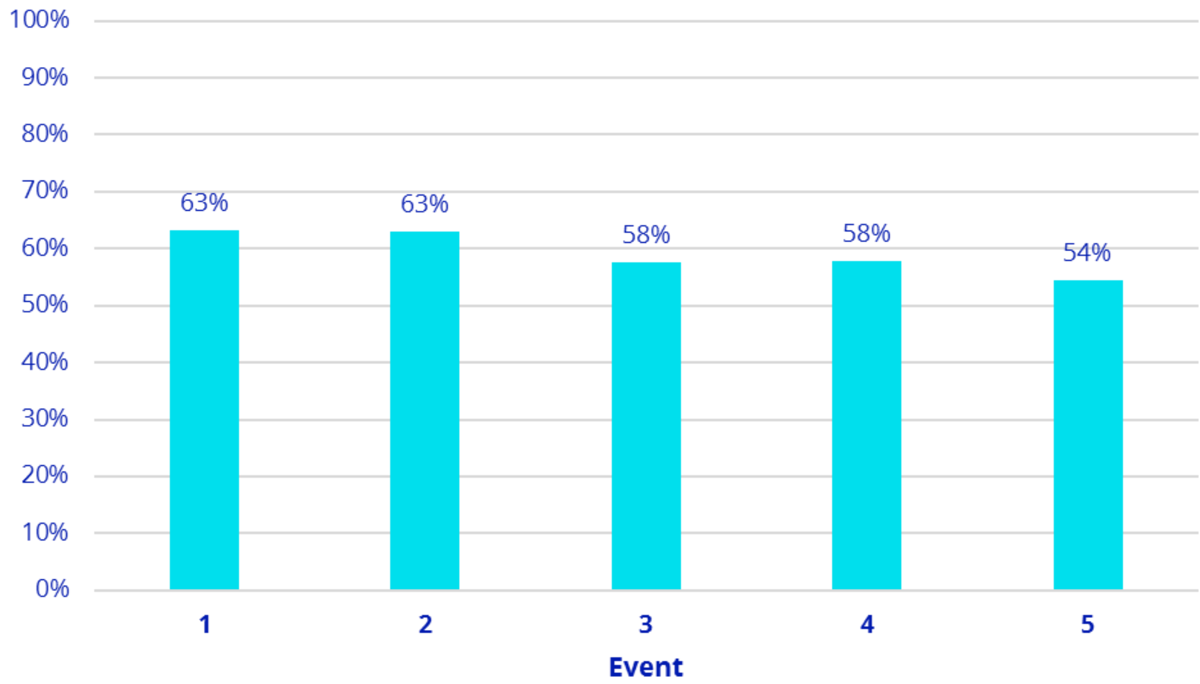

Figure 4 – Event participation rate

Figure 5 shows the average load reduction across all events of participants that indicated in the pre-event survey that they would participate. There are several findings from this data:

The top 20% of participants delivered 80% of the demand reduction. 30% of participants in the events didn't reduce, or actually increased, their consumption.

In the "more than 0.7kW" category, the most successful participant recorded an average demand reduction of 6.4kW. This is likely to be a large property with a high energy consumption.

Very high levels of demand response are rare, however, with the majority of participants achieving a load reduction of between zero and 0.3kW.

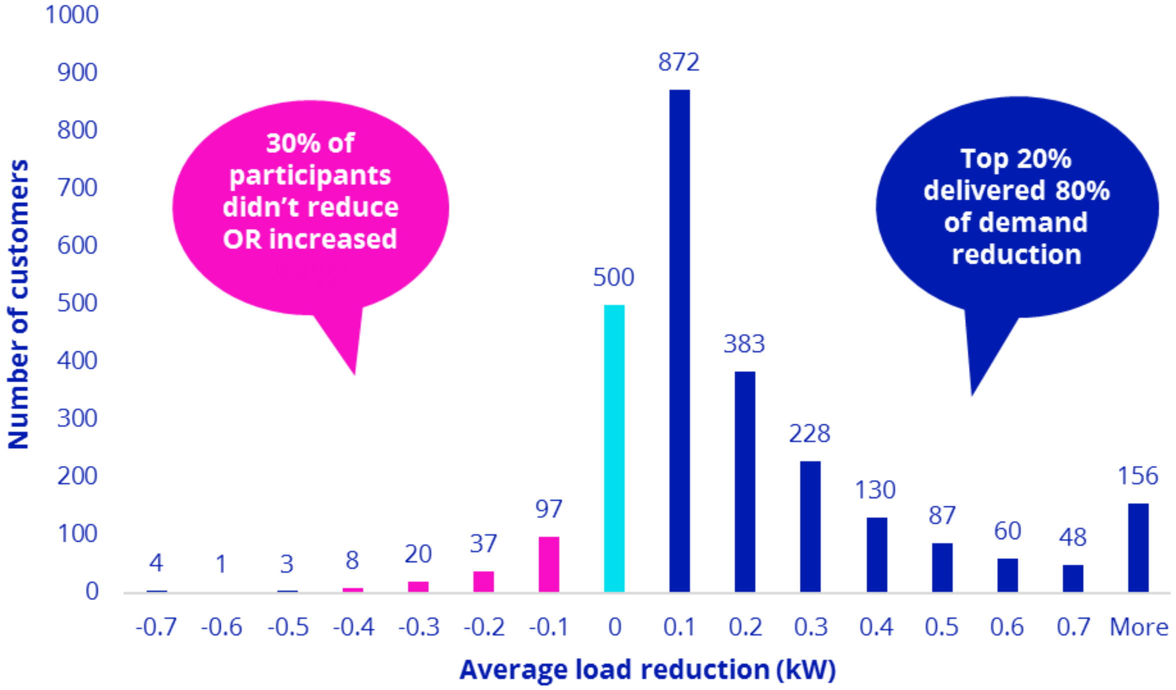

Figure 5 – Average demand reduction histogram across all events

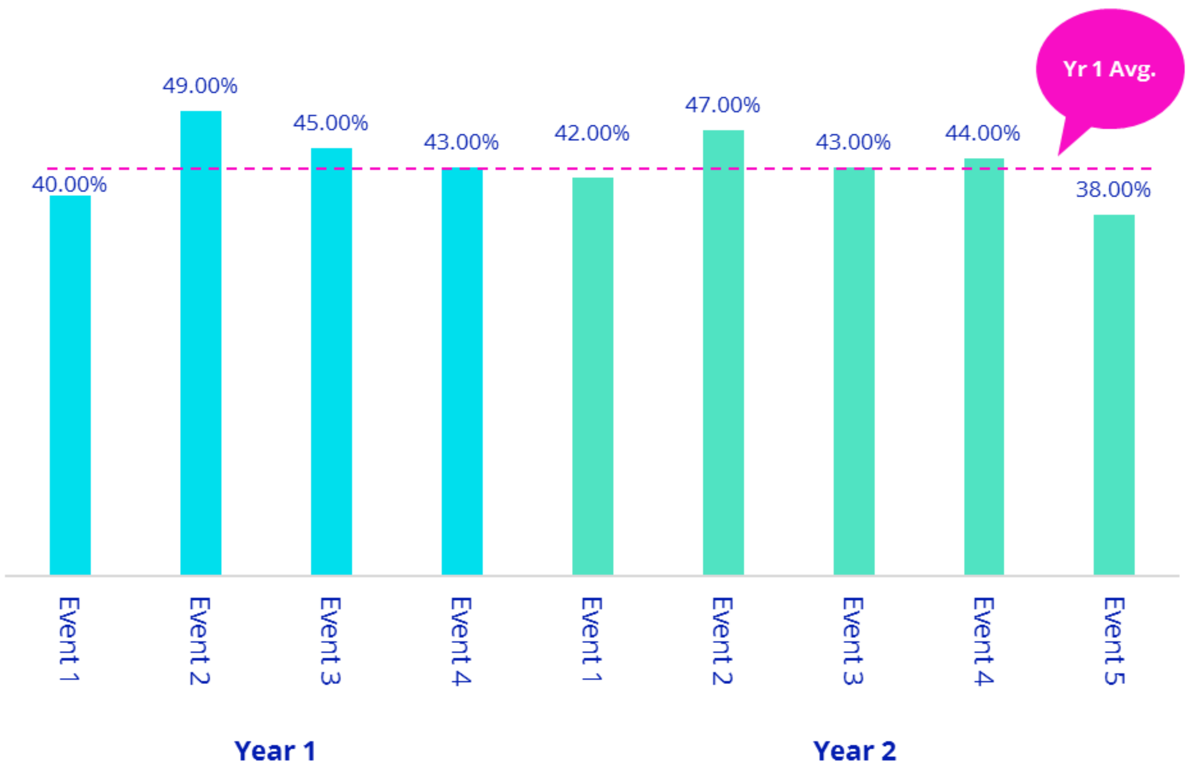

Figure 6 – Percentage load reduction of participants across Year 1 and Year 2

Across the summer, the percentage load reduction performance of the actively participating Year 2 cohort was very similar to that of Year 1, as illustrated in Figure 6.

There were issues identified with customers that have solar installed on their house. This represented 30% of the Year 2 cohort. As solar customers are more engaged in their electricity supply, they are more likely to be attracted to a DR program, and the percentage of solar customers in the program was higher than that across the rest of AGL's NSW residential customer base.

Unfortunately, the introduction of solar into the forecasting/baseline equation adds another layer of uncertainty, as solar irradiance at the time of the event may be different to forecast on a macro or micro geographical basis. Solar output from a residential array can vary significantly throughout the day and this variation can overwhelm the DR efforts of the participants, leading to customer dissatisfaction if their efforts are not rewarded. This was reflected in some of the survey responses.

Conversely, in the case when solar output is higher than forecast, the customer may be paid for what appears to be DR but would have happened anyway.

This issue could be addressed by using separate (gross) metering for the solar output, however the majority of residential solar metering in NSW is net metering and the solar circuit is not measured separately.

4.3.7. Customer research

A customer survey was undertaken after each event, with a larger survey held at the end of the summer program. Completed surveys were received from nearly half of the program participants, with responses slightly skewed towards more active program participants.

Survey results indicate that the program was positively perceived by customers:

- 90% were highly satisfied with the program.
- 96% would sign up for next year's program.
- 92% would recommend the program to family and friends.
- 90% said the program would make them more likely to stay with AGL.
- 89% said their experience with the program made them feel more positive towards AGL.
- 88% said AGL was innovative in bringing something new to customers.

Other useful information to come from the survey and the event performance data:

- 64% of participants achieved at least one target across the summer. 5% achieved target 1 in all five events and 3% achieved target 2 in all five events. 36% of participants did not achieve any targets in any events.
- Post event survey results across the program suggested that there was a 25% occurrence of false negatives (customer tried to reduce but was not rewarded) and 41% of false positives (customer did nothing but was rewarded anyway). Some of this may be due to the solar issue mentioned earlier, or customer uncertainty about which appliances will contribute significantly to a demand reduction.

- The event length of two hours as per the current program design was preferred by most participants, however events of three or four hours duration are likely to receive a lower level of support.
- A majority of customers said they would be willing to participate in events on consecutive days (which was not trialled).
- Most customers participated in the program in order to receive the financial rewards and reduce their electricity bill. The vast majority of customers preferred the bill credits used in Year 2 to other forms of reward (including the gift cards used in Year 1).
- 70% of respondents liked the timing of event notices in the Year 2 program (one the day before the event, one an hour before the event, one an hour after the event with the results). However, 29% would prefer to receive a notice 48 hours before an event, with a reminder at 9:00am on event day.

4.3.8. Year 2 conclusions

The second year of the residential behavioural program provided further insights into the acceptance and effectiveness of behavioural demand response at the residential level, together with more clarity on the costs and practicalities of implementing such a program.

For DR programs to be possible, smart interval meters must be installed in customer premises. AGL installed 1,500 smart meters in late 2018 specifically for this program. However, we had intended to install 2,300 meters and encountered 800 installation failures (35%), largely due to access problems. The penetration of smart meters in NSW is still relatively small; the widespread adoption of DR at the residential level is likely to be problematic until it is much higher.

The program received positive responses from most customers who were engaged by it. Survey responses from this group indicated a high level of interest and excitement about being involved in something new. Nevertheless, there was also some dissatisfaction expressed by customers who had been disadvantaged by forecast/baseline inaccuracy, by target achievement that had been reduced or eliminated due to variations in solar output, or who thought they had done a lot to reduce their demand but had not achieved anything.

Some of the latter group may be helped by further education; some survey comments indicated customers had been doing things like turning off appliances on standby, which is often cited as an energy saving measure but is not effective for DR. However, it is also true that there were customers who genuinely tried and achieved a load reduction but were disadvantaged by the inherent imprecision of the forecasting and baseline process.

The provision of in-event feedback during Year 2 was a mixed success. The requirement to generate a load forecast ahead of event day in order to set targets and show performance against those targets introduced another level of potential error that disadvantaged some customers. Across the events, between 20% and 40% of event participants engaged with the monitoring portal, with the number reducing over time. The DR results were higher for those that did engage with the portal by around 30%, but it’s not clear if this was due to their use of the portal or because they were more engaged customers who would have performed well anyway.

The cost to implement and run the in-event feedback portal was significant, in particular for the provision of the near-real-time metering data, and in a commercial DR program this cost would ultimately need to be recovered. Also, with the incentive structure used in Year 2, the cost of incentive payments for residential DR was high compared to wholesale market spot prices.

4.4. Year 3

For the third year, the program was extended to 8,000 customers and modifications were again made based upon the lessons learnt from the previous year.

The monitoring portal was continued but only for those customers who had had it in Year 2 – new participants just received the SMS notifications of events. Changes were also made to the forecasting algorithm to reduce the lead time necessary prior to calling events.

The program performed strongly again, however the NSW bushfire crisis, the Covid 19 pandemic and cool weather in autumn curbed activity and only three test events were ultimately executed.

4.4.1. Recruitment

The customer cohort for the third year of the program was slightly over 8,000 customers in NSW. The recruitment process was similar to year 2 (refer section 4.3.1), with the following enhancements to achieve the greater number of customers required:

- The campaign started earlier and ran for a longer period.
- Resumption of a sign-up bonus (used in Year 1 but not Year 2).
- More aggressive re-targeting of customers from the previous year (around 80% of Year 2 customers signed up for Year 3).
- More experimentation and tailoring of EDM messaging to further refine the offer.
- Two rounds of re-targeting EDMs to customers who had not responded to the previous EDMs, as opposed to one previously.

4.4.2. Incentives

The incentive program for Year 3 was structured differently to Year 2, with event rewards based on a "beat your forecast" base reward together with two further target-based rewards for further demand reduction.

To overall incentives for Year 3 were:

- A sign-up bonus of $10.
- A $5 reward to "beat your forecast" – any load reduction against the calculated forecast for that customer.
- Two payments of $5 for reaching further pre-set load reduction targets.

Incentives were paid via bill credits. The maximum possible payment per event was $15.

4.4.3. Monitoring portal

For Year 3, the monitoring portal was restricted to those customers who had already had it in Year 2 for a number of reasons that included:

- Issues experienced in Year 2 with the meter exchanges necessary to install the particular smart meter needed to support near-real-time meter data (refer section 4.3.8).
- Further constraints around the installation of smart meters in NSW brought about by new network tariffs and the possibility that customers would be financially worse off following a meter change.
- The high cost of running the monitoring portal.

4.4.4. Target setting

The “deep learning” method used to forecast customer load and set targets in Year 2 was deemed to be unsuitable for scaling to the size of the Year 3 customer cohort due to the high computational load and long lead time required for events. It was discontinued for Year 3.

Targets for Year 3 were set using a simple aggregation percentile range method, which determined target percentiles from the fast aggregation of historical smart meter data from each site.

For each event, the first target was set at 0% reduction (“beat your forecast”), the second at 20% load reduction and the third at 40% load reduction. The low threshold of the “beat your forecast” target was intended to drive customer engagement through the earning of at least one reward for doing relatively little. Once the customer was engaged, then it was possible that they would go further and try to earn additional rewards.

4.4.5. Event results

Three test events were held for the portfolio across the 2019/20 summer. More events had been planned, however several external factors intervened:

- The serious bushfire situation in NSW caused the suspension of test events from December through until late January.
- The Covid 19 pandemic was creating a great deal of uncertainty in the community from March onwards and it was felt to be unwise running tests in this environment. It would also be possible that results during this period would be skewed by the temporary demographic changes caused by the pandemic, making them less valuable for predicting future results.
- Cool weather after summer made the execution of further events relatively pointless, given the already established correlation between event results and temperature.

Results for the three events were similar to Year 2. To enable a direct comparison to Years 1 and 2, the same anchoring baseline has been used to measure load reduction performance.

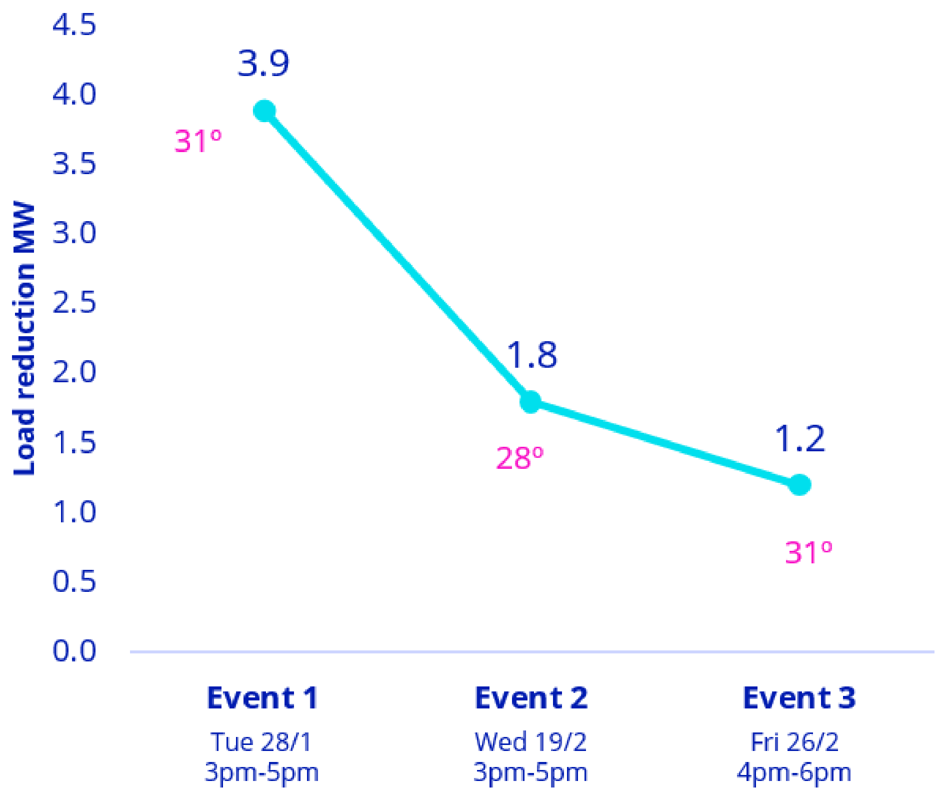

Figure 7 – Aggregate event results for residential behavioural program in Year 3

The participation rate for the Event 1 was 70%, slightly higher than the 63% achieved for the same event in Year 2, perhaps reflecting the improved marketing communications and modified incentive structure.

As with Year 2, the top 20% of Year 3 participants delivered nearly 80% of the demand reduction. Figure 8 shows the histogram for Event 1.

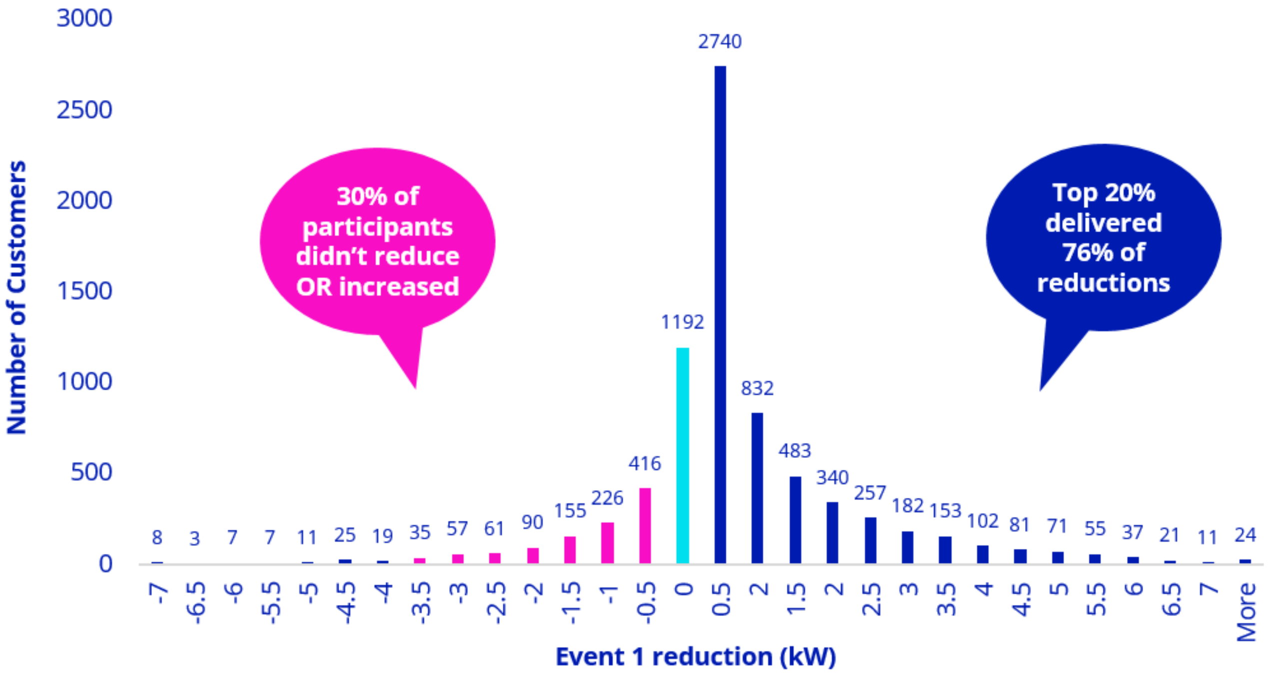

Figure 8 – Demand reduction histogram for event 1

4.4.6. Customer research

Survey results throughout Year 3 were again very positive, with over 900 responses received:

- 96% were highly satisfied with the program.
- 97% would sign up for next year's program.
- 82% said the program made them proud to be AGL customers.
- 90% said the program would make them more likely to stay with AGL.
- 91% said their experience with the program made them feel more positive towards AGL.
- 90% said AGL is innovative in bringing something new to customers.

4.5. Lessons Learnt from the Behavioural Program

4.5.1. Customer engagement

The behavioural program has shown extraordinary levels of customer engagement and approval, much higher than most of the other experimental programs that AGL has undertaken with residential customers in the past few years.

Some of the reasons for this include:

- There is no financial outlay by the customer to participate – they don't need to buy anything.

- It's not necessary to understand or install any technology to participate, so customers who have a fear of technology or are unfamiliar with it can join the program.
- The customer can earn money to reduce their electricity bill.
- It's not mandatory for customers to participate in events – they can ignore them if they like.
- Customers feel that they are part of the solution to the problems in the electricity grid and are providing a community service by participating in the program.

The high level of customer engagement has turned out to be a significant positive for the program and is part of the reason that AGL has continued with the program beyond the trial (refer section 4.6).

4.5.2. Baselines

A key issue for any demand response program is the estimation of how much energy would have been consumed by a customer if they had not taken any load reduction measures. This estimate is called the baseline.

Under the RERT program, AEMO supplies the baseline formula against which the aggregate demand response is measured, however it is up to the aggregator to determine how each individual customer should be incentivised to participate.

For the commercial and industrial part of this project, AGL used the AEMO baseline formula for all participant baseline calculations (refer section 6).

For the residential part of the project, however, AGL determined that the AEMO baseline formula was not well suited to the large variations seen in residential loads and would likely lead to significant customer support issues if we attempted to use it to recompense customers for their DR efforts. Therefore, for the residential part of this project, we used an in-house baseline methodology developed from the experience gained in a previous demand response trial conducted at Carrum Downs, Victoria.

The AGL baseline averages the usage at a particular time of the day for days of a similar temperature over the last five weeks (differentiating usage on a weekday or weekend) and anchors it to the actual consumption before and after the event. It is calculated using the following steps:

- Generation of a site level forecast based on regression of the previous five weeks net load (load – solar), excluding any controlled load channels, against temperature, time of day and workday/non-workday.
- De-biasing by comparing the previous seven days forecasts against the actuals for the same time of day as the event period and adjusting the event period baseline forecast.
- Anchoring the predicted consumption outside the event period to the actual consumption on that day, based on smoothed consumption either side of the event period.

While AGL's baseline performed very well, some problems were noted. In some cases, false positives occurred when the baseline methodology detected a load reduction for customers who did not actively change their behaviour. False negatives occurred when the baseline methodology did not detect a load reduction for customers who genuinely did change their behaviour, including customers who actively left the house much earlier in the day to avoid being home during the event – a scenario that is not well handled by an anchoring baseline.

A key issue for demand response in a residential setting is that, under different temperature and household energy use scenarios, different results will be achieved, ie the same behaviour change or action may produce a different monetary reward from event to event. Energy reduction is highly temperature and weather dependant, so turning the air conditioner off when the outside temperature is 40º will have a different demand reduction effect to doing the same thing when the outside temperature is 32º. This is further complicated by variations in direct solar radiation on the house and windows on different days.

Baselines present an interesting challenge for residential demand response programs, and the variable nature of rewards calculated from baselines can introduce confusion and disengagement if customers don't understand the complexities behind them.

4.5.3. Amount of demand reduction per customer

The amount of demand reduction that can be achieved from residential behavioural demand response is quite temperature dependent, with the better results in hot weather suggesting that much of the load reduction is coming from air conditioners.

Across the program, the amount of demand response achieved per customer, for those customers who actually reduced their load, averaged 0.6kW when the temperature was above 31°C, with a maximum load reduction of 0.9kW when the temperature was 39°C, and 0.8kW when the temperature was 40ºC (bearing in mind that these are central Sydney temperatures which are not always reflective of the temperature in Western Sydney or greater NSW).

Conversely, the amount of load reduction dropped to around 0.1 – 0.3kW per household when the temperature was below 30°C, suggesting that air conditioners were not operating on those occasions and any other devices in the house that could be curtailed were relatively low consumers of electricity.

The average demand reduction across the whole program for those customers that actually reduced their load was 0.5kW, suggesting that, as an order of magnitude, around 2,000 actively participating customers are needed per MW of load reduction.

4.5.4. Solar

In recent years, residential metering in the NEM has moved to a net metering model where import and export power flows are combined at the meter into two registers for each measurement interval – a net import register showing the total energy imported into the site, and a net export register showing the total energy exported from the site[2]. While this is a simple approach to data collection and billing, and

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[2] Net metering for import/export has replaced the gross metering model that was used in the past to measure solar generation separately from household consumption. With gross metering, the net-off happens upstream in the billing computer rather than on site. There are still some gross metering installations in the field, but they are becoming fewer as time passes.

potentially means that the meter hardware is a little cheaper, it also means that specific data on the energy produced by rooftop solar arrays is not available.

This creates a problem measuring demand response as there is no way to differentiate between changes in household consumption and changes in solar output. This means variations in solar output may be mistaken for DR, or genuine DR efforts may be nullified by variations in solar output.

For example, a cloud mass passing over a property at the time of a DR event will reduce the output from the solar array, increasing household consumption from the grid. If the homeowner has taken steps to reduce their demand for the event, depending on the size of the reduction compared to the increased grid consumption the demand reduction may not be recognised in full, or at all, or may even be registered as a demand increase. This creates a perception issue in the eyes of the customer, who may have taken all reasonable steps to participate in the DR event but has received little or no reward.

Conversely, a cloud mass that clears early in a DR event will reduce household consumption from the grid due to increased solar generation. This may look like a DR response when compared to the aggregator's baseline, when in fact the customer has done nothing. This may lead to a customer being rewarded for zero effort.

The increasing prevalence of solar across residential customers means this issue will become more problematic with time.

This problem is difficult to solve with the current net metering model. The best solution would be a return to gross metering, where the solar output is measured on a separate register in the meter and can be excluded from the DR calculations altogether.

4.5.5. The 80/20 rule

A consistent theme across the program was the 80/20 rule – 20% of participants deliver 80% of the demand reduction. This leads to a quandary for DR aggregators – if the program was being undertaken strictly for demand response value, then the aggregator would target the top 20% of participants during recruitment to avoid the costs of managing the other 80% for little return.

In practice, AGL favoured the customer engagement benefits of the program over the demand response benefits and did not specifically target the high performers, however this will be an issue for future behavioural DR aggregators to consider.

4.5.6. Smart meters

Smart (interval) meters are essential for a demand response program – they are the only way that consumption reductions at a specific time can be recognised. At present these meters allow a 30-minute resolution, but this will progressively reduce to five minutes with the implementation of five minute settlement in the NEM in late 2021.

Victoria is currently the only state with a high penetration of residential smart meters, close to 100%. Other NEM states have smart meter penetrations in the order of 15%; this is growing, but only slowly under current policy settings.

Consequently, Victoria is the only state where a large-scale rollout of residential demand response can occur without in-field meter replacements being necessary.

AGL undertook several thousand in-field meter replacements in NSW as part of this project. There were issues with an uncomfortably high percentage of these, many of which could not be completed in a timely manner, mostly due to lack of access to meters in multi-unit developments. This will be a challenge for Meter Providers at some point in the future.

A further barrier to the installation of smart meters was the implementation of new time-of-use or demand-based network tariffs by some Distribution Network Service Providers in NSW, with these tariffs being made mandatory when a meter is upgraded to a smart meter. The new network tariffs will lead to higher bills for a significant portion of the population and presently act as a disincentive for these customers to upgrade to smart meters. These customers could be worse off financially because of the meter change, even when the additional benefits of participating in a demand response program are counted.

4.5.7. Near-real-time feedback

The results of the trial suggest that the provision of near-real-time feedback to customers during events does positively impact their performance. However, once the cost of providing this feedback is taken into account, the benefit is far less clear cut and AGL has proceeded beyond the trial without the use of feedback (see section 4.6).

The cost of providing near-real-time feedback was high because it cannot be provided as a matter of course by the “smart” interval meters used in the national electricity market. It could be argued that these meters are anything but smart by 2021 standards, in an era where the real-time collection of data from all sorts of internet-connected devices is performed routinely and presented instantly to smartphone apps at our fingertips. The collection of metering data once per day (the “day after” data used in the NEM) is an outdated model developed at the time of dial-up modems and has been rendered obsolete by technological developments since that time.

4.5.8. Target setting

The “deep learning” method used to set individual customer targets in Year 2 was an interesting experiment but ultimately deemed unsuccessful. It had the following disadvantages:

- It was expensive to compute and data hungry. Computing the targets for the relatively small Year 2 cohort of customers took many hours and precluded events being called at short notice.
- It required timely localised event weather forecast data, which was generally not available, to maximise accuracy.
- Solar customers required an additional model of the PV system to infer gross load from net load data, which introduced additional complexity and uncertainty.
- It could not scale to a larger customer cohort.

A simpler percentile range target setting approach was used in Year 3. This required less data, was less dependent on localised weather information, did not require a separate solar model and was faster to compute.

4.5.9. Other BTM DER assets

With the increasing use of behind-the-meter distributed energy assets, there is a looming clash between these and the successful operation of residential behavioural demand response. The issues with variable solar output have been discussed in section 4.5.4, however these are compounded by the increasing use of solar and other behind the meter assets as remotely controlled distributed energy resources. Examples of this include:

- The disconnection of rooftop solar from the network for grid stability purposes.
- The increasing prevalence of batteries and their enrolment into virtual power plants where they may be dispatched for network, wholesale market or frequency contingency services purposes.
- The various air conditioning control schemes being operated by some networks and retailers.

The operation of these devices presents a further challenge to the accurate forecasting and baselining of residential loads for behavioural DR and will almost certainly lead to errors and double counting in DR payments with resultant customer dissatisfaction.

4.5.10. Yearly recruitment

Due to the increasing customer targets in each year of the ARENA program, AGL conducted a recruitment process annually. This recruitment required a significant commitment of resources for many months, increasing each year as the number of enrolled customers increased.

Based on this experience, we believe annual recruitment is probably not an optimal model for future years. A better model would be one of either:

- Including a roll-over provision in the demand response contract that would automatically enrol customers the following year unless they opted out.
- Including demand response as part of the standard residential energy supply agreement so that all customers were automatically enrolled in the program unless they opted out.

Either of these models would significantly reduce the recruitment workload and cost, although some additional marketing cost may need to be incurred keeping customers engaged during the off-season.

4.6. Behavioural Demand Response – Beyond the Trial

AGL extended the behavioural demand response program into Victoria for the 2019/20 summer (Year 3 of the NSW program). Over 11,000 customers signed up for the program in Victoria.

On Thursday 13 February 2020, AGL released the following announcement to the ASX at the same time as the half year results announcement:

AGL customers to benefit from Demand Response program next summer following successful trials

AGL is pleased to announce our Peak Energy Rewards demand response program will be expanded to other states before next summer following successful trials in New South Wales and Victoria.

Demand response helps customers in reducing their electricity demand at a particular time of day. It can be an effective way to help reduce individual customer bills, improve reliability and reduce the average cost to supply electricity to all households and businesses.

This year more than 8000 customers are involved in the NSW trial which is the final year of a three-year program in partnership with the Australian Renewable Energy Agency (ARENA), the NSW Government and the Australian Energy Market Operator (AEMO). AGL extended the program into Victoria in December with over 11,000 customers joining, highlighting the strong demand in other states.

AGL Chief Customer Officer, Christine Corbett, said the program would be made available to up to a million customers before next summer across New South Wales, Victoria, South Australia and Queensland.

"The response to this program has been overwhelmingly positive and we are proud to be able to offer it more widely across Australia, because it means more customers will reap the rewards and save on their bills," Ms Corbett said.

"The results and feedback from this program have been fantastic – customers who participated in the trial saved an average of 30 per cent on their usage during peak events.

"On top of that, it delivered benefits to the energy grid and we saw significant, consistent load reductions across all peak events.

"The best part is that being involved in the program doesn't cost customers anything, there's no need to pay for equipment or install anything. It's free, voluntary and accessible for anyone with a smart meter.

"The program utilises data, along with weather information, and our digital platform to deliver highly personalised communications to the customer helping them to reap the benefits on offer.

"We see orchestration initiatives like this, and our Virtual Power Plant, as providing mutual benefits to AGL and our customers, as technology and the energy grid continues to evolve. It's a way of putting more control in the hands of our customers while reducing demands on the grid," Ms Corbett said.

Over 50,000 customers signed up for the program for the 2020-21 summer in Victoria, NSW, Queensland and South Australia. Portfolio dispatches were undertaken with after consultation with AGL's wholesale markets division. Alongside the commercial and industrial portfolio, the residential behavioural portfolio was also potentially available for short notice RERT contracts with AEMO in NSW and Victoria, although was not dispatched.

In in mere four years, thanks largely to this ARENA and NSW Government demand response project (which, as well as AGL, included other retailers such as Powershop and Energy Australia), residential behavioural demand response has gone from a fringe offering to mainstream. Challenges remain, however the concept now has widespread acceptance as a method of engaging customers and offering them greater flexibility in relation to their electricity supply.

5. Residential Controlled Load DR

5.1. Introduction

The objective of AGL's "Peak Energy Rewards – Managed For You" program was to trial the direct remote control of large residential loads whose use would ordinarily coincide with peak demand periods on the electricity grid.

It comprised two elements:

- Remote control of air-conditioners.
- Remote control of home EV chargers for a small number of customers with electric vehicles.

The program was held over 2018/19. Installation of the necessary hardware in customer homes began in the second quarter of 2018, although the installation phase for the air conditioner program took much longer than expected and events were not able to be run until early 2019.

5.2. Air Conditioner Program

5.2.1. Recruitment

An electronic mail campaign was undertaken in early 2018 directed at customers in the Sydney area with a smart meter who had higher than average energy consumption and high energy use on hot days. The recruitment campaign consisted of a targeted email linking to a registration form on the campaign web page.

Despite offering an upfront incentive of $300, the response rate for this program was significantly lower than that for the Peak Energy Rewards behavioural program, which had a much smaller upfront incentive of $50.

To participate in the trial, customers had to own an air conditioner that was compliant with Australian Standard AS4755 "Demand Response Capabilities and Supporting Technologies for Electrical Products" to allow the air conditioner to be remotely controlled with a Demand Response Enabling Device (DRED). Many air conditioner manufacturers advertise compliance with this standard with their current models. Nevertheless, AGL anticipated some air conditioner compatibility issues prior to customer recruitment and therefore restricted eligibility for the program to customers with:

- an air conditioner less than five years old
- makes and models of air conditioner that we could cross-check for AS4755 compatibility prior to the site visit, using compatibility tables provided by the air conditioner manufacturers.

In practice, many customers had considerable difficulty determining the model number of their air conditioner. Often the required information was on the nameplate on the outdoor unit which may not be safely accessible. AGL frequently had to email and/or call customers repeatedly to obtain the relevant air conditioner make/model information, which created a significant workload in onboarding customers to the program.

Of the 123 initial expressions of interest, around 40% were found to have an air-conditioner that was not compatible with AS4755 and were excluded from the program. A further 10% of customer registrations were abandoned because the customer gave up trying to find the information or could not be contacted by AGL.

From the initial 123 enrolments in the program, only 45 successfully proceeded to installation.

Following equipment installation, one customer churned from AGL, and there were complications with another customer's air conditioner. These two customers were removed from the trial and the trial proceeded across the 2018/19 summer with a total of 43 customers.

5.2.2. Technology and Installation

AGL engaged a Sydney-based electrical contractor with air conditioning experience to install the remote monitoring and control equipment at each participant site.

Demand Response Enabling Devices (DREDs) and energy monitoring devices were installed in 45 houses in the greater Sydney area during 2018. DREDs are designed to send a signal to the air conditioner to restrict the unit to 0%, 50% or 75% of "normal" energy consumption, averaged over a half hour period.

Both the DREDs and the energy monitoring devices were connected to a remote server using the customer's Wi-Fi network and internet connection. Events were remotely triggered by AGL via an API, and air conditioner load data was collected every 15 minutes using the energy monitoring device installed in each home specifically for the purpose.

For those customers with an AS4755 compliant air-conditioner make and model, site visits were arranged to install the equipment. In completing the installations, the installation contractor had to contend with many complexities on site including:

- Compliance with AS4755 is not "plug-and-play". In many cases, an additional adapter from the air conditioner manufacturer was required to interface the air conditioner with the DRED. There is no standardisation of adapters across brands, and many variants of adapters exist even across air-conditioner models of the same brand. The contractor spent a lot of time travelling to/from parts suppliers trying to obtain the correct adapter for the air conditioner at hand.
- Many of the adapters and other interface parts did not have clear installation instructions.
- A second (or in some cases a third) visit to site was often required, in many cases inconveniencing the customer.
- Some air conditioners did not fully implement the demand response modes defined in AS4755, or did not correctly interpret the commands, requiring modifications to the DRED installation or back-office server configuration in order to make the installation work correctly.

Installations were tested for end-to-end communications and correct operation of the remote commands before the installation contractor left the site, although determining which DR mode is active in an air conditioner is difficult to do quickly and accurately on-site, given the cycling nature of air conditioners and differing (possibly low) ambient temperatures at the time of installation.

It was found that the response of air conditioners to the standard control commands varied, with different air conditioners responding to the commands in different ways. Individual end-to-end testing was required for each installation, and in some cases re-mapping of the control commands was necessary to force the installation to behave according to the standard.

5.2.3. Event communications

Customers were advised of the test events by SMS the day before the event and at the time of the event. This was a courtesy only – customers didn't have to respond to the SMS or do anything proactively because the control of their air conditioner was being remotely managed. The SMS provided details of who to call if the customer wanted to opt-out or had any problems during the event.

5.2.4. Test results

There were two test events held for the air conditioner program:

Event No	Date	Temperature	Event time	No. of a/c	Fleet ave kW reduction	Ave kW reduction per a/c
1	Tuesday 5/03/2019	Sydney 28.6° Penrith 36.2°	14:00 – 16:00	9	16	1.8
2	Thursday 21/03/2019	Sydney 26.6° Penrith 28.8°	15:00 – 17:00	7	11	1.6

For the first event, the fleet was instructed to apply to the 75% energy consumption mode for all air conditioners. There were no opt-outs by customers, but only nine air conditioners were running and able to participate, probably due to the lack of people at home at that time of day.

Due to an absence of status feedback from the air conditioner back to the DRED (and hence to the back-office), a degree of interpretation of the consumption data is necessary to determine how each unit behaved during the test. Using this method, three of the nine units participating dropped to 50% power and four of the units dropped to zero power. This was not consistent with the command to drop to 75% power.

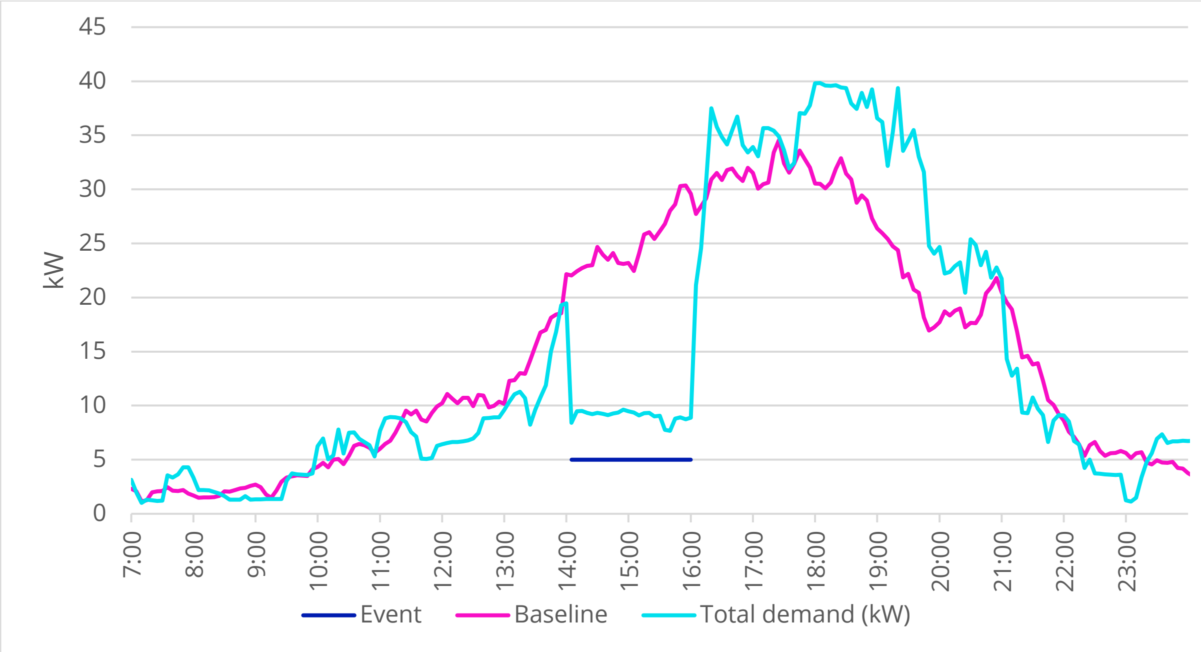


Figure 9 – Air conditioner program event 1 results

For the second event, the weather was slightly cooler and only seven houses had their air conditioners running and available to be controlled during the event. The command was again to move to the 75% consumption mode. There were no customer opt-outs.

Six of the air conditioners appeared to drop to zero consumption, which again was not consistent with the command issued.

One air conditioner used more power during the event, not less. The reason for this is not clear. Given the power usage either side of the event was minimal, it's possible that the customer turned the unit on at the time of the event. The absence of any feedback of air conditioner status through the DRED makes conclusive analysis of these occurrences difficult.

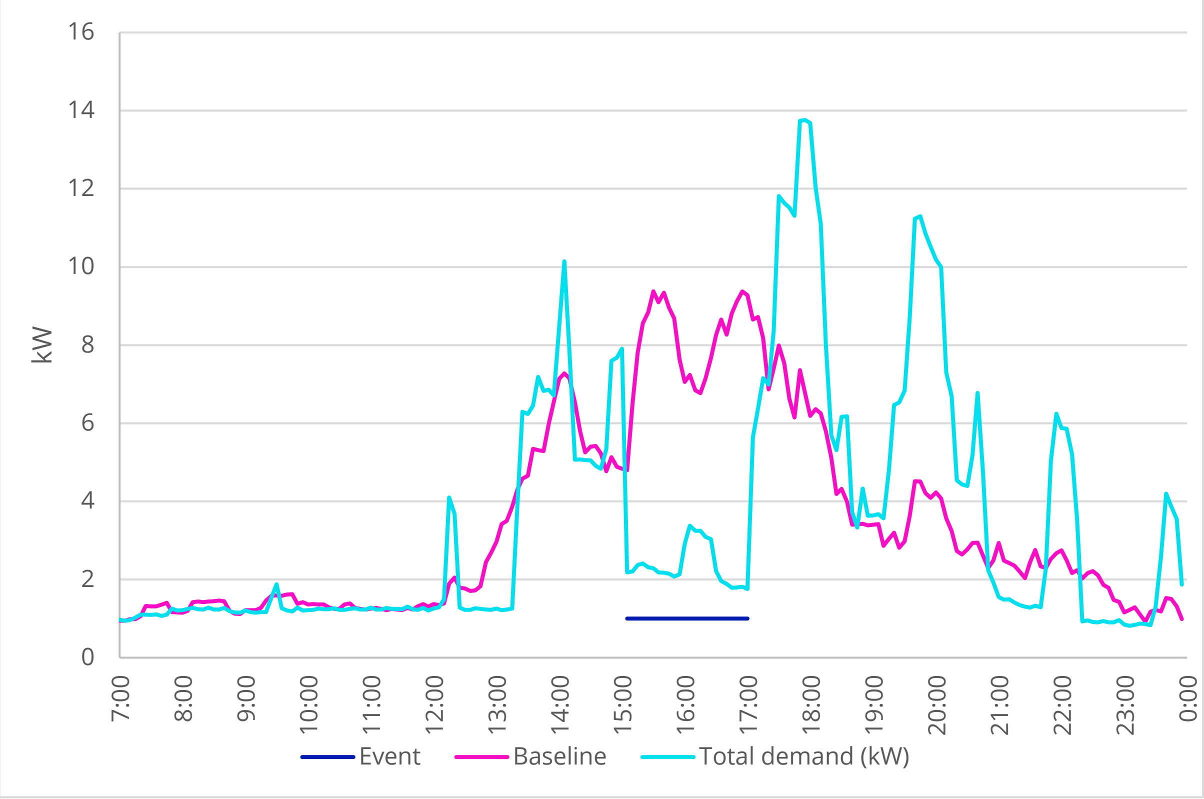


Figure 9 – Air conditioner program event 2 results

5.2.5. Performance analysis

The modest participation rates reflect the likelihood of people being home at the time of the events – air conditioners must initially be on if they are going to be controlled off. There were good results in terms of load reduction where air conditioners were operating, but some complaints afterwards about how their air conditioner was being controlled and there was evidence that many air conditioners were capping energy consumption at 0% or 50% rather than the intended 75%.

There was a spike in demand at the conclusion of both events as the air conditioners ramped up output to reach temperature setpoints again. More advanced control would need to be implemented to return the air conditioners to normal operation without causing a demand peak after the event.

Some participants reported specific problems with comfort levels to AGL's customer relationship managers during or after the events. In one case this correlated with an air conditioner that had set itself to zero consumption.

Nevertheless, the survey results at the end of the trial were generally positive:

- Almost 90% of responses had little or no concern about having their air conditioner managed.
- 78% said they would recommend the program to others.

- 42% said the main reason for participating in the trial was the financial incentives, while the remainder were interested in helping the grid, or just wanting to be involved in something new and novel.

The DREDs send a signal to the air conditioner to restrict the unit to 0%, 50% or 75% of "normal" energy consumption, averaged over a half hour period. Whilst the Australian Standard specifies how this is to be measured, there were differences in operational performance noted between air conditioner makes and models, and it was frequently difficult to verify which mode an air conditioner was actually using from looking at the measured consumption data.

Further investigation was unable to find a link between the unexpected behaviour of air conditioners during the test events, specific air conditioner makes/models, or the test results recorded at the time of commissioning. As the system was performing in an unexpected way and some customers were being inconvenienced, a decision was made not to conduct any further events.

5.2.6. Conclusions

Although the program demonstrated that a reduction in power consumption can be achieved from a portfolio of air conditioners during demand response events, there were several important observations:

- Air conditioners can only be controlled if they are turned on in the first place. In practice only around 20% of units in the trial were turned on at the time of the two events, both of which were held on weekday afternoons when grid supply issues are likely to occur.
- For customers whose air conditioner was turned on and able to be controlled, the average load reduction was 1.7kW, but this result was due to many of the units reducing energy consumption to zero rather than the requested 75%. In some cases, customers reported problems with comfort levels.
- The demand response benefits are less obvious when the air conditioner does not reduce consumption to zero and an adequate comfort level is being maintained. If the air conditioners had correctly executed the 75% consumption mode command, the average load reduction per unit would have been in the order of 0.6kW.
- There are many practical issues related to the DRED control methodology specified in AS4755, particularly when retrofitting the devices to existing air conditioners in the field. These include:
    - The bespoke nature, complexity and high cost of the installations, the resultant inconvenience to customers and the high skill level required of installers.
    - The inconsistent response of different makes and models of air conditioners to the control commands.
    - The lack of a feedback mechanism from the air conditioner to confirm that it has successfully executed the command that it has been given. Trying to determine this retrospectively from consumption information was problematic in the trial and suggested that in many cases the air conditioners either didn't interpret, or couldn't execute, the command correctly.

- There is no local override capability if the customer wants to opt out of an event after it has started. This currently requires a phone call to the electricity company, which is an inconvenience to the customer and takes time to execute. Ideally a local override button would be on the air conditioner itself, or perhaps operated by an app.
- There is no factoring of room temperature into the control methodology; the algorithm only aims to cut power consumption, which it will do at the expense of comfort.
- The Australian standard measures the target consumption reduction of an air conditioner as an average over half an hour. At times, the instantaneous demand will be much higher than this. As a result, a group of controlled air conditioners in a specific network area can still generate high demand peaks on the local network. From a wholesale market perspective, the benefit of a half-hour average demand reduction following the implementation of the five-minute market in late 2021 is questionable.

The retrofitting of DREDs to existing residential air conditioners uncovered many issues with compatibility, reliability, feasibility and cost. Due to the complexity of the DRED installation, the time the installation contractor spent at customer sites was significantly more than planned, often with repeated visits, not only increasing costs but also becoming a significant impost on customer's time.

AGL's conclusion from this trial is that the remote control of existing (already installed) air conditioners for demand response is not currently viable using the technology specified in AS4755. While this may be improved if the air conditioners were fitted with the appropriate control technology at the factory and/or during installation, concerns remain around the approach used in AS4755, its impact on comfort levels, its effectiveness if comfort levels are not impacted and the lack of a local override capability.

Innovations in internet-connected domestic appliances and internet control technology in recent years have already left AS4755 behind. Wi-Fi enabled smart devices are now becoming relatively commonplace in the home. Two-way high-level communication with these devices is standard; the basic one-way communication specified in AS4755 is now out-dated. Manufacturers routinely maintain IT platforms that communicate with their population of field devices en-masse, and can provide APIs to allow other parties to access these devices under suitable agreements. If air conditioner control is to be used for DR purposes in the future, it is far more likely to be achieved using this type of technology that that specified in AS4755.

5.3. Electric Vehicle Program

5.3.1. Recruitment

Electric vehicle trial participants were recruited via a targeted email campaign to selected NSW AGL customers who were on AGL's existing electric car plan. Twenty-four registrations were received with fourteen customers proceeding through to installation of a smart charger.

Key insights gained through the electric vehicle recruitment process were as follows:

- EV owners are highly engaged and connected to their peers, with a conversion rate from email to registration of 40%, and 16% of recipients forwarding the recruitment email to a friend.

- Despite initial interest many applicants did not proceed, with 25% of registrations not replying to correspondence or committing to the formal participant agreement.

Once eligibility was confirmed, customers were onboarded through a welcome email and welcome pack that outlined the program details and expectations.

5.3.2. Technology and installation

A Schneider EV Link Wallbox smart charger was installed at each participant's house, connected to the customer's Wi-Fi network for internet access. This was a relatively straightforward process and there were no significant issues with the installation or operation of the chargers.

The chargers were controlled via some simple trial software developed by Chargefox, with the customer able to manage their participation in the events via the Chargefox phone app.

5.3.3. Event communications

Participant communications were:

- An SMS alert delivered 24 hours before the start of the event, including an opt-out via email.
- A Chargefox app notification at the start of the event, including an opt-out via a button in the app.
- A Chargefox app notification at the end of the event.
- An SMS message with a survey link five minutes after the end of the event.

5.3.4. Test results

AGL undertook five test events between July 2018 and March 2019, as detailed in the following table:

Event Number	Date	Start time	Duration (hours)	Number of EVs	Total average kW reduction	Average kW reduction per EV
1	Tuesday 24/07/2018	17:00	2	7	25.3	3.6
2	Tuesday 26/02/2019	16:00	2	1	2.8	2.8
3	Thursday 07/03/2019	17:00	2	4	8.8	2.2
4	Wednesday 13/03/2019	17:00	2	3	9.9	3.3
5	Tuesday 26/03/2019	14:00	2	0	0	0

Unlike air conditioners, EV charging load is not correlated to ambient temperature and forecast temperature was not a factor in selecting the test dates. Tests were scheduled on weekdays selected randomly by AGL, with most event times concentrated in the late afternoon or early evening during the period when most EVs were expected to be already at home or about to arrive home.

When a DR event started, vehicles plugged in and charging at the time had their charging activity curtailed and re-commenced at the end of the event. Vehicles returning home during the event had the commencement of charging deferred until the end of the event.

5.3.5. Performance analysis

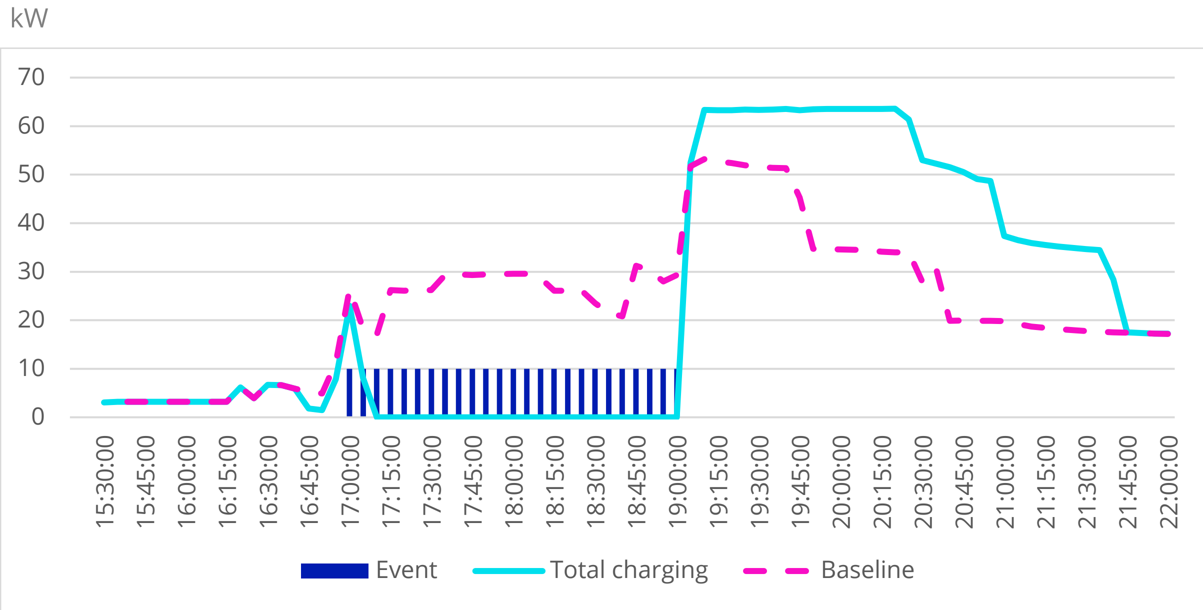
Analysis of existing charging data prior to program commencement suggested that the earliest time that worthwhile charging deferral could be achieved during weekdays was 5:00pm. Earlier times were trialled in Events 2 & 5. The single vehicle present for Event 2 and zero vehicles present for Event 5 confirms this hypothesis, albeit with a small sample size.

The tests also demonstrated that new peaks can be created at the end of an event when delayed charging is restarted for all vehicles at the same time. If a large vehicle fleet was being controlled in similar DR events, it may be necessary to consider more comprehensive control strategies to prevent new peaks at either the local network or system level.

No participants opted-out of events at any stage during the program.

During the trial there were some teething issues experienced with the control system operating the chargers, particularly in the early stages, however these did not compromise the program. Some customers reported difficulty logging into the app, however this issue was largely resolved after the first event.

The average load reduction per vehicle plugged in and participating was around 3kW across all test events.



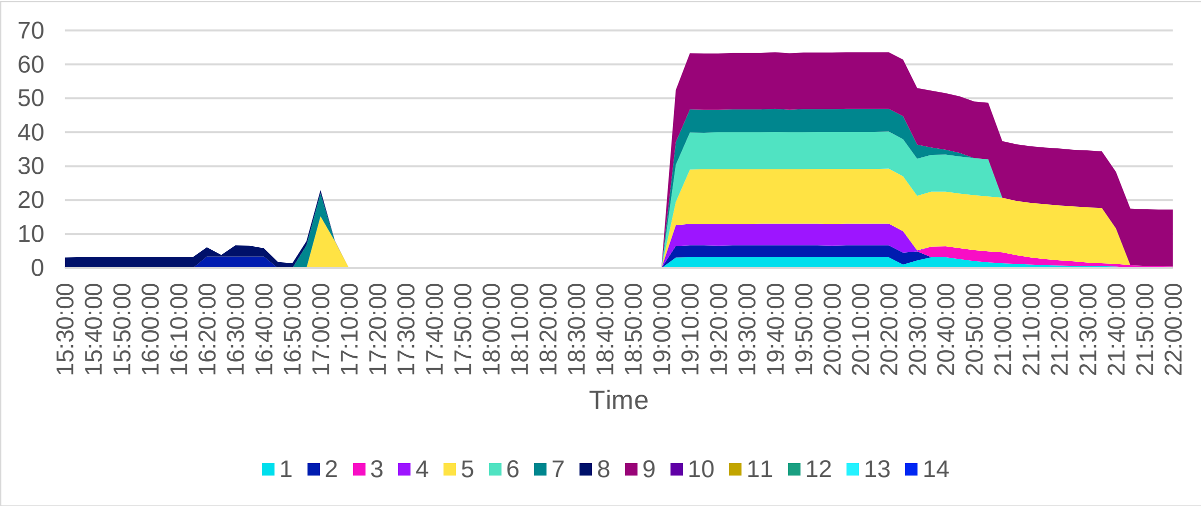


Figure 11 – Typical EV event graph, overall and per vehicle, Event 1, 24/07/2018 17:00-19:00

5.3.6. Survey responses

A customer survey was held after each event and a more detailed survey at the conclusion of the program. The average response rate to the event surveys was 28%, with a response rate of 36% to the final survey.

Survey responses were overwhelmingly positive, with comments and suggestions about possible improvements. A common request was for more information and greater visibility of the results at the individual level and for the overall population of participants. All survey responses said that they would recommend the program to other electric vehicle owners. Overall satisfaction towards the program itself and to AGL for conducting it ranged from 90% to 100%.

The main negative issue identified in the surveys were occasional problems logging into the app, and one customer seems to have had repeated concerns with this throughout the trial.

5.3.7. Conclusions

The key insights from the electric vehicle program were:

- EV home charging is a potentially significant and highly deferrable load.
- EV owners are supportive of efforts to manage the impacts of their charging on the grid.
- Deferring charging has the potential to create a new coincident peak if all charging resumes at the same time.

The trial demonstrated that the home charging of privately-owned vehicles could be successfully controlled to avoid system peaks. In all cases the charging load was reduced to zero. The fact that no participants opted out of any events, together with the very positive survey results, suggest that this happened in a way that was largely transparent to the customers and did not inconvenience them.

Nevertheless, some caution should be exercised in interpreting these results as both the trial itself and the survey responses were a small sample. Most of these customers are likely to be “early adopters”, who may be more aware and engaged in electricity supply issues than the general population.

The results of the trial indicate that the day-ahead notification of DR events is unnecessary and could be removed without any significant impact on customer perception or load reduction. The ability to opt-out at any time remains a key customer requirement, however, and gives customers the comfort that their charging requirements will be met on those occasions when their charging pattern varies from normal. The highly engaged EV customer cohort also appreciates feedback of DR results after events.

More comprehensive charging control could be established with the aim of achieving a full vehicle charge by early morning, for example 5:00am or 6:00am, allowing more flexibility in the timing of charging and a much later charge commencement time following the evening peak. At scale, this could be coordinated to enable further integration of renewables into the grid and to maximise the utilisation of existing network infrastructure without costly augmentations.

5.4. Lessons Learnt from Controlled Load Program

5.4.1. Air conditioning program

Recent technological improvements have the potential to create low-cost, high-value opportunities to intelligently manage behind-the-meter distributed energy resources (DER) at the residential level.

However, at this stage, AGL has found that complex customer and technology challenges still exist in the deployment of orchestration for household air conditioning. Complex on-site installation processes to enable DR functionality in already installed air conditioners is not commercially feasible at present with the cost of the installation exceeding the benefits.

Despite offering more substantial financial rewards than the behavioural demand response program, AGL found that successfully recruiting customers into a program requiring the customer to give up some level of control of appliances also has challenges, including the willingness of customers to be at home during business hours to meet the installation contractor.

5.4.2. Electric vehicle charging

The trial demonstrated that electric vehicle charging could be a substantial controllable load with the potential to be shaped and managed. Further investigation is necessary to determine the limits to which this can be achieved without adversely impacting vehicle amenity, and to further examine customer acceptance on a larger scale. Although the technologies require more development to be truly customer friendly and have the necessary back-office functionality, the basics are in place and there are no major technical barriers to further adoption. The hardware cost of smart chargers is expected to reduce over time such that they are likely to be the routine choice for home charging within the next few years.

At this stage, the potential benefits of electric vehicle charging control are only limited by the relatively slow take-up of electric vehicles in Australia.

5.5. Controlled Load DR – Beyond the Trial

5.5.1. Air conditioning

AGL has not proceeded with air conditioning control of the type testing during this trial.

A further trial is currently underway using internet-connected infrared blasters to control air conditioners via the infrared connection normally used by the remote control. Whilst this approach is not free from issues, the IR blasters are relatively low cost and can be self-installed by the customer, negating many of the problems experienced during the ARENA trial. This trial is not yet complete.

5.5.2. Electric vehicle charging

Buoyed by the results of the electric vehicle charging component of this project, AGL applied for and received funding from ARENA for a much larger and more comprehensive trial of EV charging orchestration[3]. This trial was announced in November 2020 and is currently in the recruitment and installation phase. The final report from this trial is due in mid-2023.

[3] https://arena.gov.au/projects/agl-electric-vehicle-orchestration-trial/

6. Commercial and Industrial DR

6.1. Introduction

Following the execution of ARENA and AEMO agreements in Oct 2017, AGL contracted commercial and industrial (C&I) customers to support 10 MW of DR from 1 Dec 2017, increasing to 17 MW in January 2018 and 20MW in December 2019.

The C&I program was open to all C&I customers in NSW – there was no requirement for participants to be an AGL retail customer.

Unlike the residential behavioural program, where several different operating approaches were trialled across the three years of the program, the operating model for the C&I program remained relatively stable for the full period of the trial, except for the gradual increase in the size of the portfolio. Some alternative technology solutions were trialled, but these were not widely adopted during the trial period.

6.2. Recruitment

AGL employed a direct marketing approach to recruit participants, contacting electricity users in NSW who had either:

- a suitable load profile.
- previously participated in a DR program.
- registered an interest with AGL to participate in DR programs.

AGL employed a telemarketer to undertake the initial customer contact. The prospective DR participant was then transferred to a DR specialist for further discussion and evaluation. Analysis of customer meter data was undertaken to estimate the customer's likely curtailment capability using a baseline checking tool that AGL has developed to help evaluate prospective providers suitability for the program. Where there was some doubt about the load reduction capability of the participant, a load drop test was undertaken. The participant was then formally contracted to the program.

Most customers contacted by AGL had not previously participated in a demand response program. AGL found that almost all organisations contacted were aware of DR and had a general interest in participating, however it is still a relatively new concept to many smaller customers and continued education and awareness programs will be necessary to help source new participants for future programs.

The financial incentive was the main motivator for most participants joining the program, however some cited being part of an ARENA program as key motivator, and some of the State and local government owned bodies have participated largely because of the perceived community benefit.

In the second year of the program, we noticed that the pool of suitable companies available to participate in the program diminished, and the success rate of recruitment dropped significantly. A possible reason for this was that most of the suitable C&I loads in NSW were contracted to a DR program already. At the time there were four ARENA-sponsored DR projects running in NSW (including AGL's), all of which rapidly expanded their C&I portfolios during 2017/18. Separately, several retailers in NSW were known to have C&I customers contracted with some form of wholesale market exposure or curtailment contract, making these loads unavailable for RERT.

Another issue that excludes many customers from participating in RERT is their operating hours. Experience in the RERT program in NSW and Victoria showed that the most likely time for RERT events was in the window 4:30pm to 7:30pm and occasionally a little later. This timing makes any site that operates in normal business hours, a single industry shift, or shopping hours (except Thursday) unsuitable for the program. Loads suitable for the RERT program need to be either a 24-hour process or at least a two-shift operation.

6.3. Incentive Structures

AGL offered participants both an availability fee and a dispatch fee for participation in the program.

The availability fee was attractive to participants generally, but particularly for those who needed to prepare before DR events. The monthly availability payments were also useful to regularly remind DR providers that they are in a DR program. This is particularly important as the success of the program is dependent on their on-going participation, with the only penalty for poor performance being a reduction or loss of payments.

Where a participant's performance varied over time, the availability fee was reset after each test or dispatch to reflect the actual capacity provided from each NMI at that time.

6.4. Customer Feedback

Feedback from DR providers indicated the main reasons for joining AGL's program were that AGL offered:

- At least one hour's notice.
- An agreement whereby providers can opt in or out, either partly (nominating specific NMIs) or entirely, without penalty.
- No mandatory requirement for remote activation.
- No up-front hardware cost (any hardware cost was covered by AGL/ARENA).

6.5. Portfolio

Following the initial recruitment ramp-up, the program portfolio remained relatively stable throughout the three years of the project, with only a small number of new participant companies coming into the program in the second and third years. The following table summarises the number of sites and industry sectors in the program across the three years of operation.

Industry Sector	Year 1		Year 2		Year 3	
	Companies	Sites	Companies	Sites	Companies	Sites
Data Centres	1	1	1	1	2	2
Telecommunications	1	3	1	2	1	5
Shopping Centres	1	11	1	9	1	10
Manufacturing Plants	1	1	1	1	2	3
Recycling Plants	1	3	1	3	1	3
Water Utilities	3	15	4	17	4	13
Universities	1	1	1	1	1	1
Total	9	35	10	34	12	37

Most of the sites in the program were in metropolitan Sydney, except for a small number of shopping centres and some provincial water utilities.

Over the three years, a small number of sites left the program for the following reasons:

- Several small sites owned by the one company were replaced by a single larger one able to be dispatched using fewer resources.
- A small number of sites were divested from their corporate parent and were no longer available to participate.
- One participant churned away from AGL as a retailer.

Only one corporate entity left the program over the three years – a water utility left the program in December 2019 as it churned to a different retailer (and is not included in the Year 3 figures above). It is encouraging that the reason this company left the program was not related to the DR program itself.

The relatively stable portfolio of participants throughout the program tends to indicate that the participants saw value remaining in the program. It should be noted, however, that the contracts AGL had with its DR participants did not bind them to a firm performance level and allowed them to reduce their performance without penalty (other than a reduction in availability and dispatch payments). This meant a company could remain in the program even if its contribution reduced below that originally contracted, with AGL taking on the risk on non-performance through over-contracting.

6.6. Technology

AGL encountered a number of issues installing DR-specific site monitoring equipment for the purpose of monitoring load in near-real time on DR sites, including:

- Customer resistance to hardware installation or SCADA integration due to a perceived cybersecurity risk.
- Customer reluctance to provide site technical resources to assist with solution implementation (generally perceived as a distraction to normal operations).
- The distributed nature of some sites – many metering points across a geographically dispersed area – made it uneconomic to install hardware.
- The cost of hardware and installation being not economic for many smaller sites (ie the cost of the equipment was higher than the DR benefit that the site delivers to the program).

For sites where installation of DR hardware was not possible, AGL employed various monitoring methods including:

- Direct login to customer energy management systems to access real-time data
- CSV files via FTP file transfer protocol from the site metering provider
- Screenshots from the site SCADA system
- Day-behind meter data from the AGL database (for AGL retail customers)
- Manual collection of meter data files from customers and/or their metering providers (for non-AGL retail customers).

By the time of our October 2019 report, AGL had ceased rolling out the hardware-based DR specific monitoring solution. Since then, the supplier of that system has made it obsolete. The small number of DR monitoring boxes that AGL had installed in the field were de-commissioned and removed where it was practical to do so.

In the last year of the project, AGL trialled the use of near real-time meter data delivered via an API from Meter Data Providers as an alternative to using separate DR monitoring solutions. The meter data API solution has the potential to greatly simplify the installation of site monitoring and significantly reduce the cost, as it uses equipment and comms channels that already exist for market metering purposes. Although, in some cases, a meter change may be required if the existing meter is an older model, the cost to do this is relatively low, Meter Providers have an established workforce able to do this across the NEM, and there is no need for any work to take place on site beyond the meter panel – something we have found to be a significant barrier to the successful completion of installation work on many sites due to site complexity and the necessity for the detailed involvement of site technical resources.

To date AGL has had detailed discussions with three Meter Data Providers who have the capability to provide five-minute near real-time data via an API. We have successfully connected to two of them using basic API tools, transferred data, and created a demonstration platform to visualise the data.

Indicative costs from Meter Data Providers suggest that the cost of site monitoring using this method will be significantly lower than the costs we have experienced installing and maintaining specific DR monitoring hardware.

Not all Meter Data Providers offer this service for C&I customers, and some of them have legacy back-office systems that are unable to provide it at present. However, discussions AGL has had with a wide range of MDPs suggest that they all know the potential value of this service and, in most cases, have it on their roadmap for development over the next couple of years.

6.7. Event Communications

Communication with participants before, during and after an event (or test) was primarily achieved through email and SMS, with the message content pre-formatted and sent from a common system. One exception to this was a participant who has requested a custom format of email message to match their internal processes, which was dealt with manually.

Participants are requested to confirm their participation in the event to an AGL DR email address, and most do this. Some also respond via SMS, which is also acceptable although it requires more effort by the dispatcher to identify the respondent.

Participants also have the phone number of the AGL dispatcher and can call if necessary. In the case of large participants with multiple sites and/or plant items to coordinate, the AGL dispatcher will often call the participant directly to discuss details of the dispatch and ensure that the process is running smoothly.

From the SMS/email system, there are two main messages that a participant will receive:

1) A “pre-notice” message, indicating that a DR event may occur at a particular date/time. This instructs the participant to be prepared for the event, but not to activate the DR until further instructed.

2) An activation message sent one hour before the event start time, instructing the participant to activate the DR at the nominated start time.

These are supplemented by some secondary messages which are sent when necessary:

1) A cancellation message that is used if an event is cancelled either before or during the event.

2) An updated pre-notice message may be sent if the proposed event time changes during the pre-notice period.

3) An “event finished” message, not part of our formal process but sent more as a courtesy and thank you.

6.8. Test Results

6.8.1. AGL test – 23 February 2018

An AGL initiated load-drop test of the NSW C&I portfolio was conducted on Friday 23 February 2018 at 14:30 NEM time (3:30pm AEDT) for one hour. Sydney weather on the test day was 27°C and partly sunny, with 32°C recorded at Penrith.

The test used the normal communications process for a real event, comprising:

- A pre-notice sent at 4:00pm the previous day indicating that a DR event was possible the following day.
- An activation notice sent one hour before the start of the event.

All entities in the portfolio at the time participated in the event, except for:

- One site for whom we already had solid test data that confirmed the expected load curtailment, and for whom the activation process had already been well tested. (This capability was also confirmed in the later AEMO tests on 28 March and 26 June when this site performed slightly above target.)
- One participant for which the hours of operation of the loads were outside the test time. This entity participated on the basis of a comms test only.
- One site that had a shortage of personnel on the day due to illness and withdrew from the event at the one-hour activation notice.

Data from the test was analysed using the AEMO benchmark formula. Including the load from (a) above but excluding the loads from (b) and (c), the test achieved an average curtailment across the two intervals of 17.11 MW, confirming the portfolio availability listed with AEMO.

	MWh	Average MW	Interval 1 MW	Interval 2 MW
Portfolio	17.11	17.11	17.00	17.23

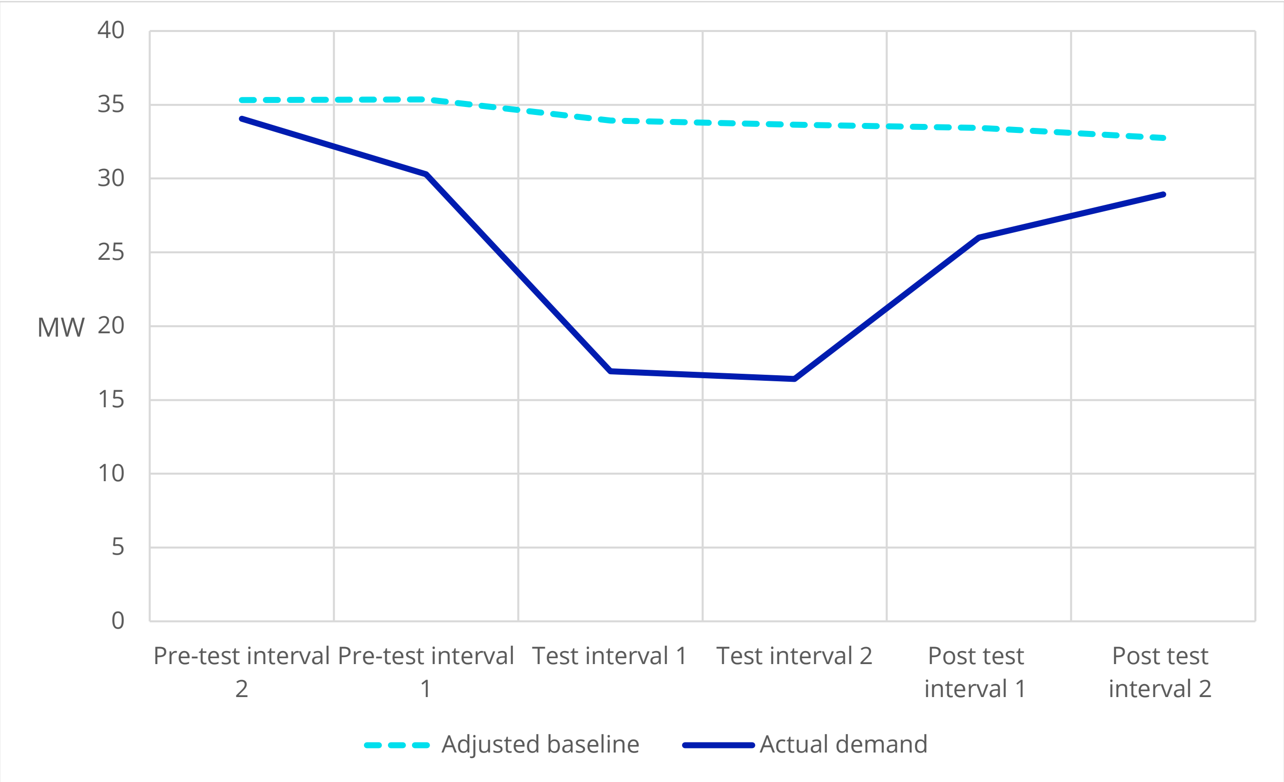


Figure 12 – Results of AGL test 23 February 2018

In general, the load curtailment of the individual participants was as expected. Some notable individual performances were:

- One water utility overperformed by about 30%
- Two water utilities underperformed by about 30%
- One industrial site overperformed by 25%.

Water utilities have previously indicated that their performance may vary depending upon which processes are running on the day, so in that respect the +/- 30% from those participants was not unexpected.

The industrial site that overperformed has a somewhat intermittent load, so its expected performance was marked down as its baseline is generally lowered due to the intermittency. It was encouraging that it exceeded expectations on this occasion. The effect of intermittency on baseline calculation is discussed further in Section 6.11.1.

Shopping centre loads performed at the expected level, assisted by the warm weather and the timing of the test.

6.8.2. AEMO test – 28 March 2018

An AEMO initiated test for the NSW SN RERT portfolio was executed on Wednesday 28 March at 13:00 NEM time (2:00pm AEDT) for two hours. Sydney weather on the test day was 27°C and sunny, with 30°C recorded at Penrith.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW
Portfolio	15.39	15.39	15.02	15.86	15.16	15.50

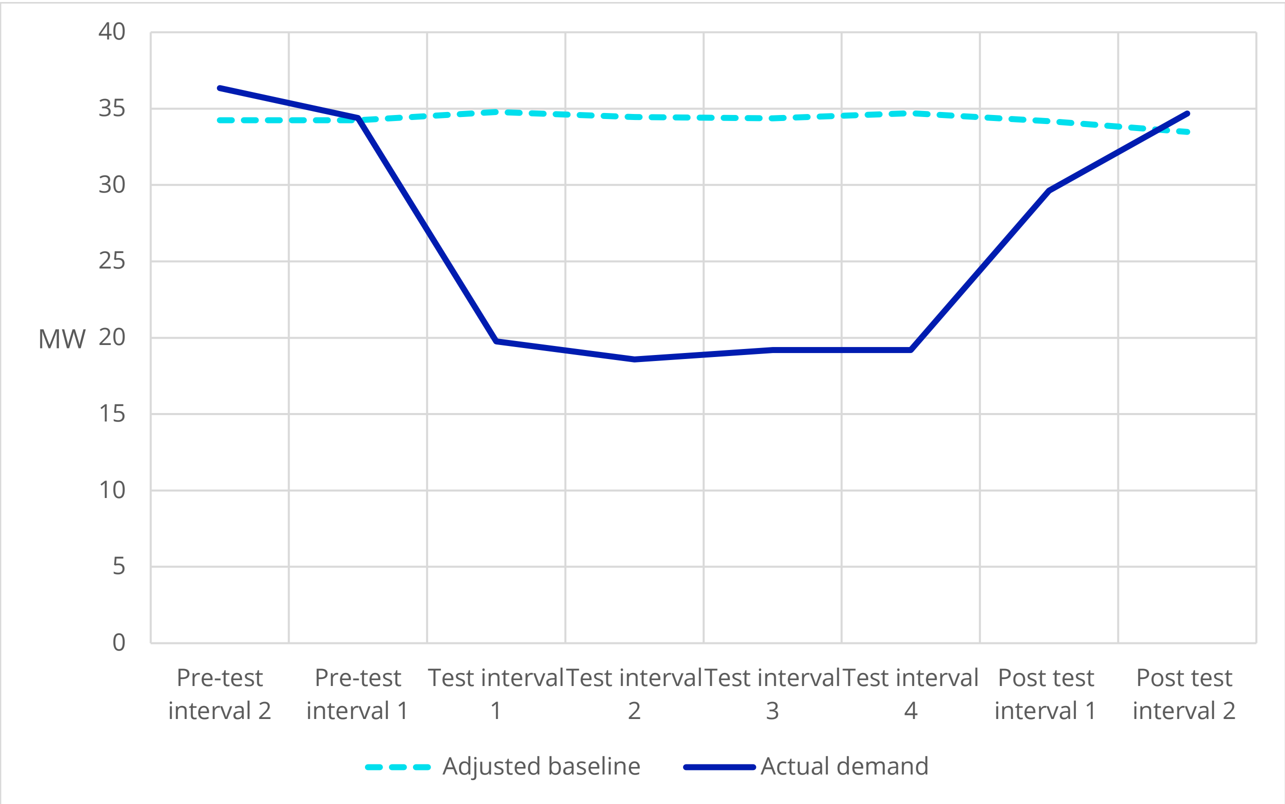


Figure 13 – Results of AEMO test 28 March 2018

AEMO reported an average reduction 15.39 MW vs the declared availability of 17 MW. Despite similar weather to that of the previous test, the aggregate load reduction was about 2MW lower and did not meet the target of 17MW.

Analysis of the data identified the major variations from the previous test as:

- The water utility that over-performed versus its nominal DR target in the previous test underperformed this time, resulting in a reduction of 2MW versus the previous test.
- One industrial site withdrew from this test at the pre-notice due to a requirement to complete a backlog of orders prior to the end of the month.
- A site that did not participate last time due to staff illness did participate this time, however its contribution was cancelled out by the shortfall from the industrial site above.

There were two main lessons from this result:

1) The fact that a water utility over-performed in the first test was not necessarily indicative of its future performance. Water utilities have flagged that their performance can vary by as much as +/- 30% depending on which processes are running on event day, and this is almost exactly the variation observed between the two tests.

2) Industrial sites that participate through the mechanism of suspending production have a higher degree of uncertainty as DR loads. For many industrial businesses, the cost of not producing for the duration of an event is significantly larger than the dispatch payments for the event. While increasing dispatch payments may partly overcome this, the cost to reputation and potential loss of customers due to non-delivery of product are generally much more important factors to a business. This may reduce the desire of manufacturing businesses to participate in DR events.

6.8.3. AEMO test – 26 June 2018

An AEMO initiated test for the NSW SN RERT portfolio was executed by AGL on Tuesday 26 June at 16:30 NEM time (4:30pm AEDT) for two hours. Sydney weather on the test day was 19°C and partly sunny, with 18°C recorded at Penrith. This was considerably cooler than the previous two tests.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW
Portfolio	17.74	17.74	17.54	17.62	17.73	18.08

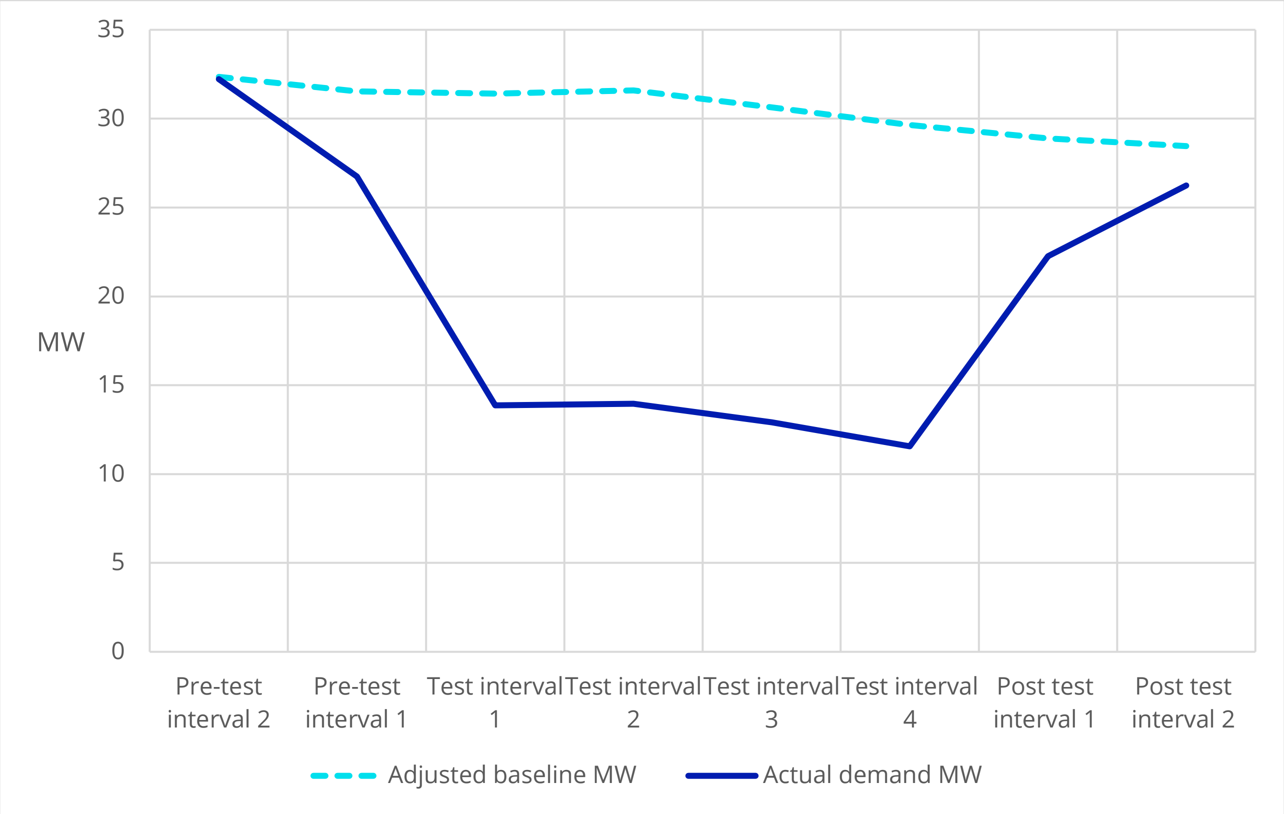


Figure 14 – Results of AEMO test 26 June 2018

AEMO reported an average load reduction of 17.74MW as against the declared availability of 17MW, slightly above target.

The main variations to the previous test were:

- A reduction by a factor of four in the average load curtailment of the shopping centre portfolio, and a marked diminution in that curtailment across the period of the test. This was due to the comparatively low temperature on the test day, together with the timing of the test during the period that that the centres were winding down their HVAC systems in preparation for closing (closing time is typically 5:30pm or 6:00pm on Tuesday).

- The addition of a new industrial customer in the portfolio that contributed just under 2MW of load reduction.
- The return of the industrial customer that did not participate last time, adding 0.5MW.

Other participants, including the water utilities, achieved similar results to the previous test.

Discounting the movement of participants in and out of the portfolio, the main lesson from this test is the marked reduction in DR achieved by the shopping centres. There are two factors at play here:

1) Most of the curtailable load in shopping centres is from air-conditioning systems. The cooler weather means that these are not running at capacity and therefore there is less load to shed.
2) The test occurred between 4:30pm and 6:30pm. The shopping centres in the portfolio close at either 5:30pm or 6:00pm on Tuesday and begin to reduce their HVAC load from around 4:30pm. The effect of this can be seen in the gap between the adjusted baseline and actual demand curves for the aggregate shopping centre load, which reduces significantly across the four half-hour intervals from the beginning of the test to the end. This reduces the average load curtailment recorded by AEMO.

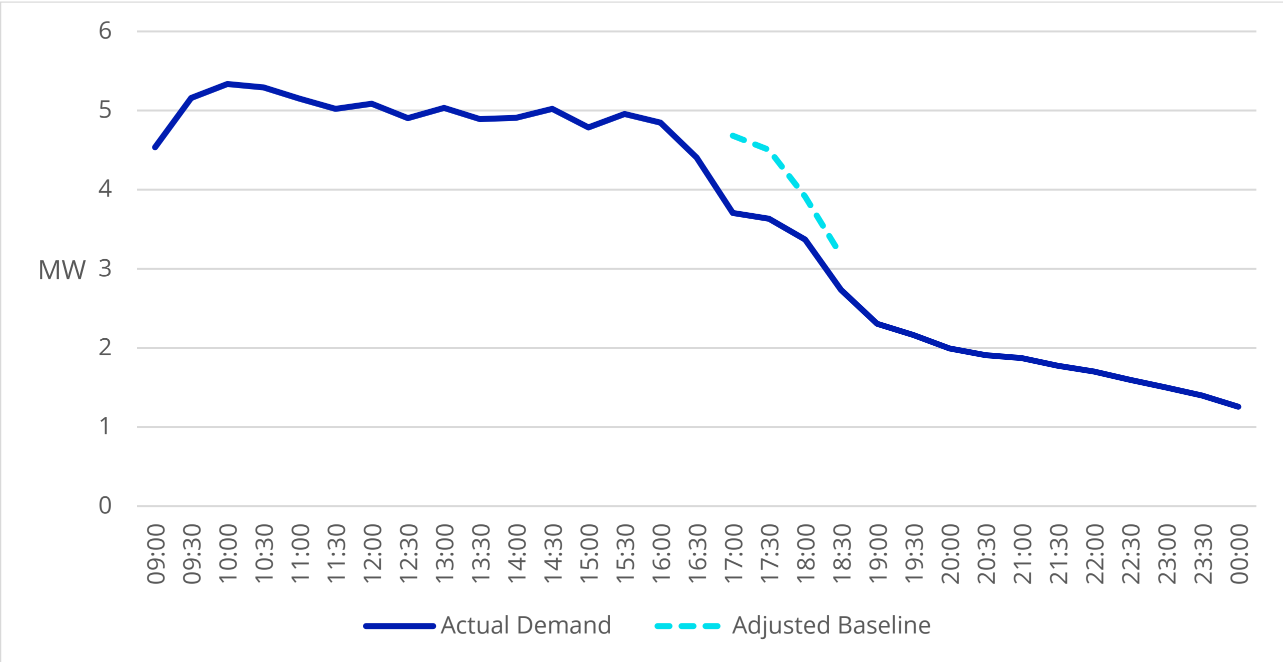


Figure 15 – Aggregate shopping centre load during test 26 June 2018

Contrast this with the result for the test on the same portfolio on 23 February, held during hot weather on a Friday (later shopping hours) and held an hour earlier in the day, where there is a much larger reduction in demand. In this case the reduction was for one hour, but could have been sustained for two hours with little diminution:

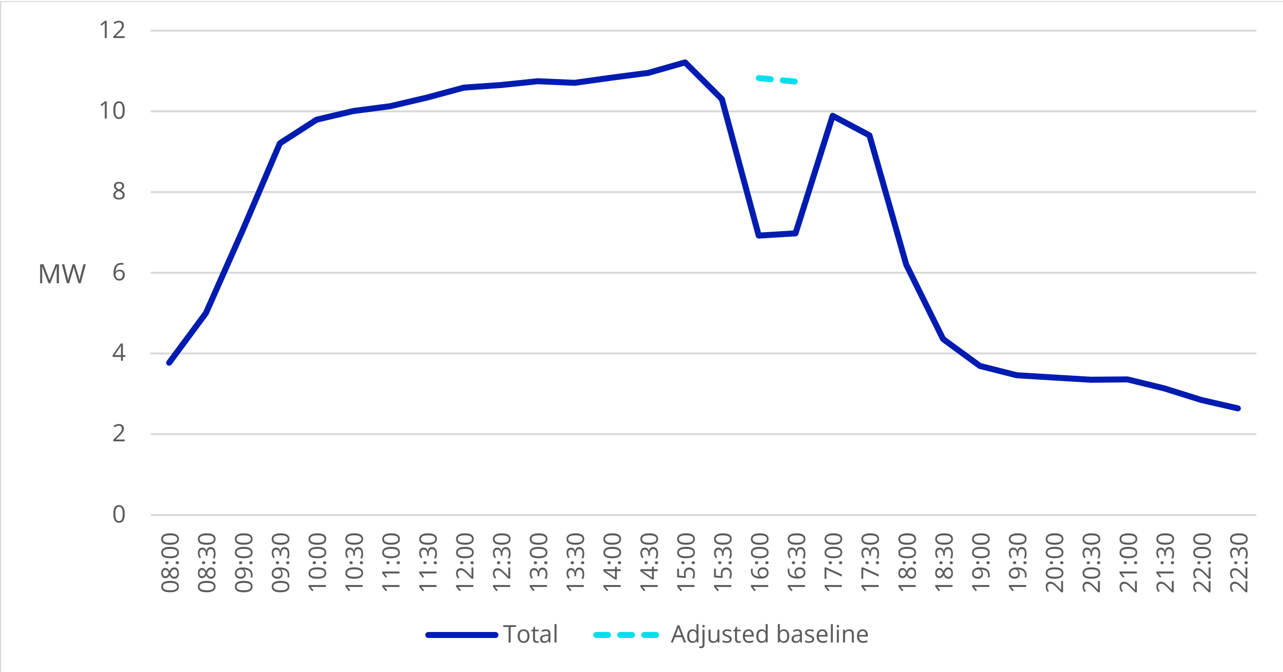


Figure 16 – Aggregate shopping centre load during test 23 February 2018

The 26 June test illustrates the significant seasonal variation in that can occur with some loads in a DR portfolio. Testing at one point in time may not reflect the load available six months later. The example here is for a shopping centre portfolio, however the same result will occur with other commercial loads where the curtailment is predominantly air-conditioning. It may also occur for pumping loads with a seasonal component.

Maintaining a DR program over winter is challenging with these loads. A 20MW summer portfolio may be totally different to a winter portfolio, leaving the aggregator with significant work to do to adjust the portfolio throughout the year.

6.8.4. AEMO test – 20 November 2018

The result of the test on 20 November 2018, held between 14:00 and 15:00 NEM time (3:00pm to 4:00pm AEDT) was an average load reduction of 12.4MW, short of the portfolio target of 17.0MW and short of the previous AEMO test result of 17.7MW on 26 June 2018.

	MWh	Average MW	Interval 1 MW	Interval 2 MW
Portfolio	12.39	12.39	11.97	12.81

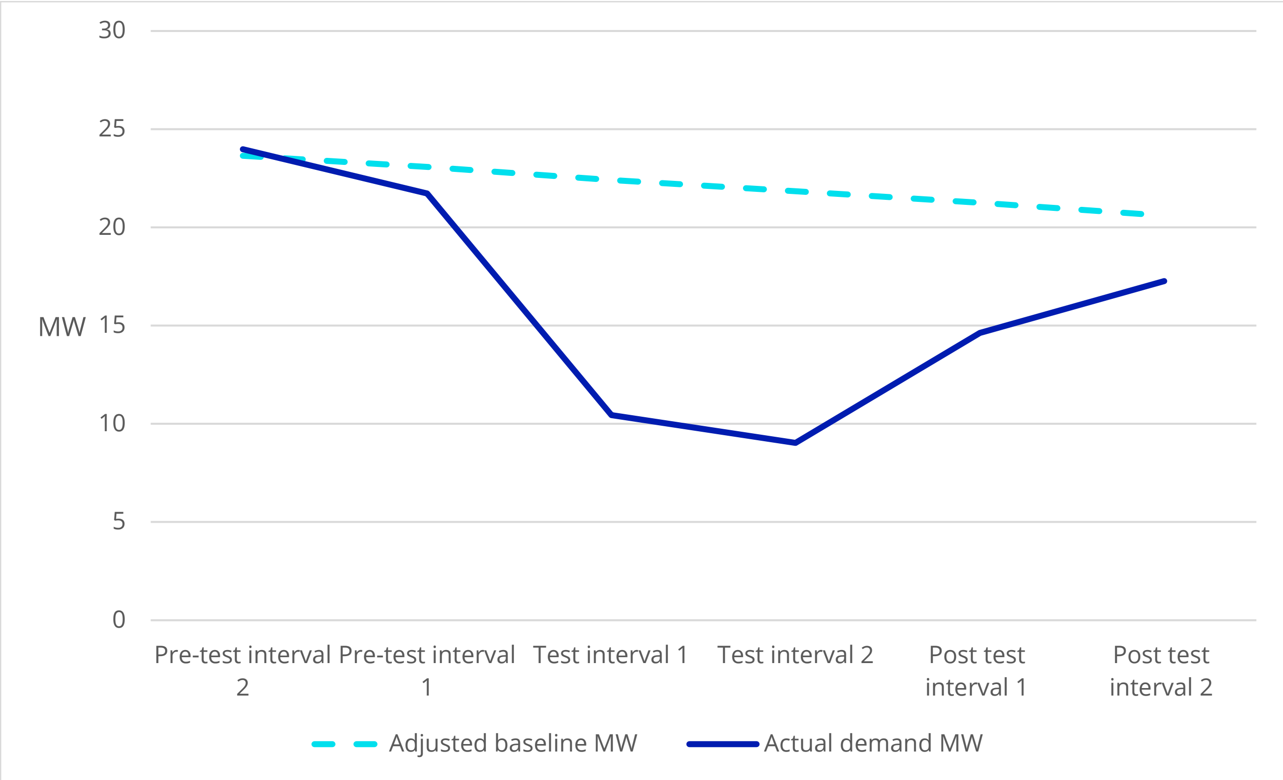


Figure 17 – Result of AEMO test 20 November 2018

A detailed analysis was performed to understand the reasons for the shortfall. The reasons identified were:

- A major water utility site was off-line for maintenance at the time of the test. Unfortunately, this was not communicated to AGL prior to the test being scheduled.
- A large industrial load that was being lightly used in the weeks prior to the test did not baseline well at the time of the test, despite reducing its load significantly on the day. This was a recurrence of the baseline problems previously experienced with intermittent loads.
- A smaller industrial load did not participate in the test, as the site needed to meet customer order commitments on the day.

- Loads with a substantial proportion of air conditioning underperformed due to the relatively mild weather on the test day (25° in Sydney and 31° in Penrith).
- One rural water utility underperformed due to water restrictions in its area reducing the normal pumping load available to be curtailed.

Unfortunately, the large water utility site that had been off-line under maintenance at the time of the test remained off-line for substantial periods over the next six months, only returning to full service in May 2019. This delayed the timing of the next test. In order to provide additional buffer to the portfolio, a further industrial participant was added to supply another 2MW of DR, and one of the existing water utility participants added a further 0.5MW – 1MW of curtailable load.

6.8.5. AEMO test – 30 May 2019

AEMO called a test of the portfolio on 30 May 2019 for the period 14:00 to 16:00 NEM time. Availability was declared at 17MW for this test in the AEMO markets portal.

The Sydney maximum temperature was a mild 21 degrees, with a similar temperature at Penrith.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW
Portfolio	42.37	21.19	21.49	21.67	21.19	20.39

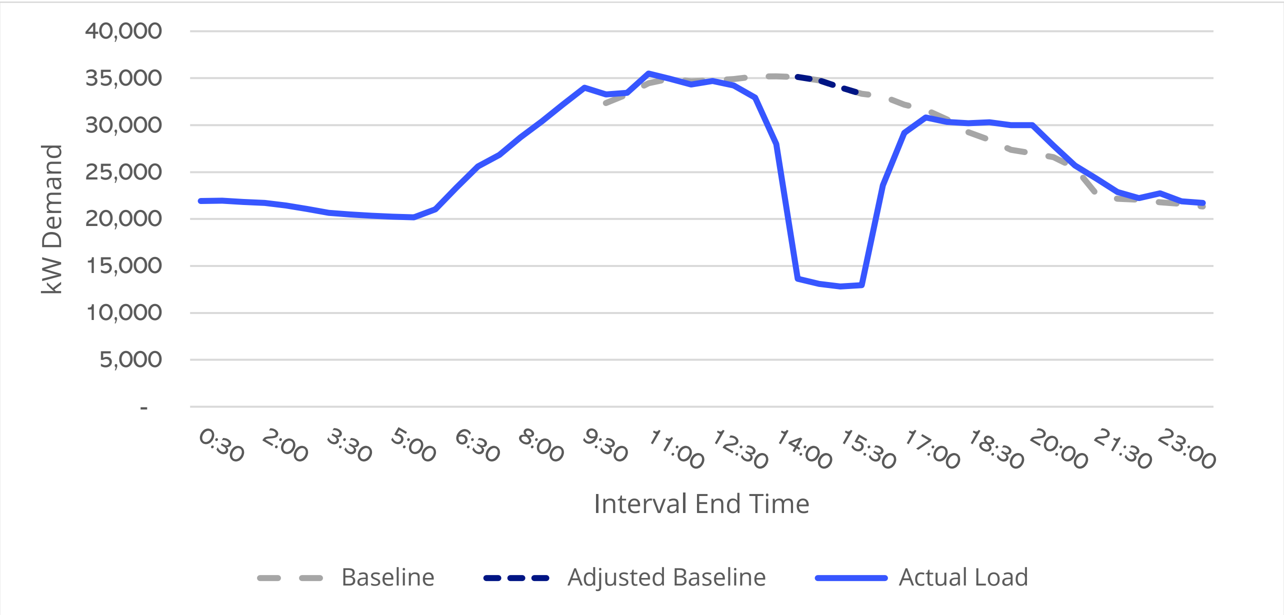


Figure 18 – Results of AEMO test 30 May 2019

This was a successful test with around 21 MW delivered, and there were no notable deviations from expected performance in the portfolio.

6.8.6. AEMO test – 4 December 2019

AEMO called a test of the portfolio on 4 December 2019 for the period 14:00 to 16:00 NEM time. Availability was declared at 20MW in the AEMO portal at the time of this test.

The Sydney maximum temperature on the day was 30.9 degrees, with 34.1 degrees in Penrith.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW
Portfolio	44.25	22.12	21.76	22.23	22.38	22.13

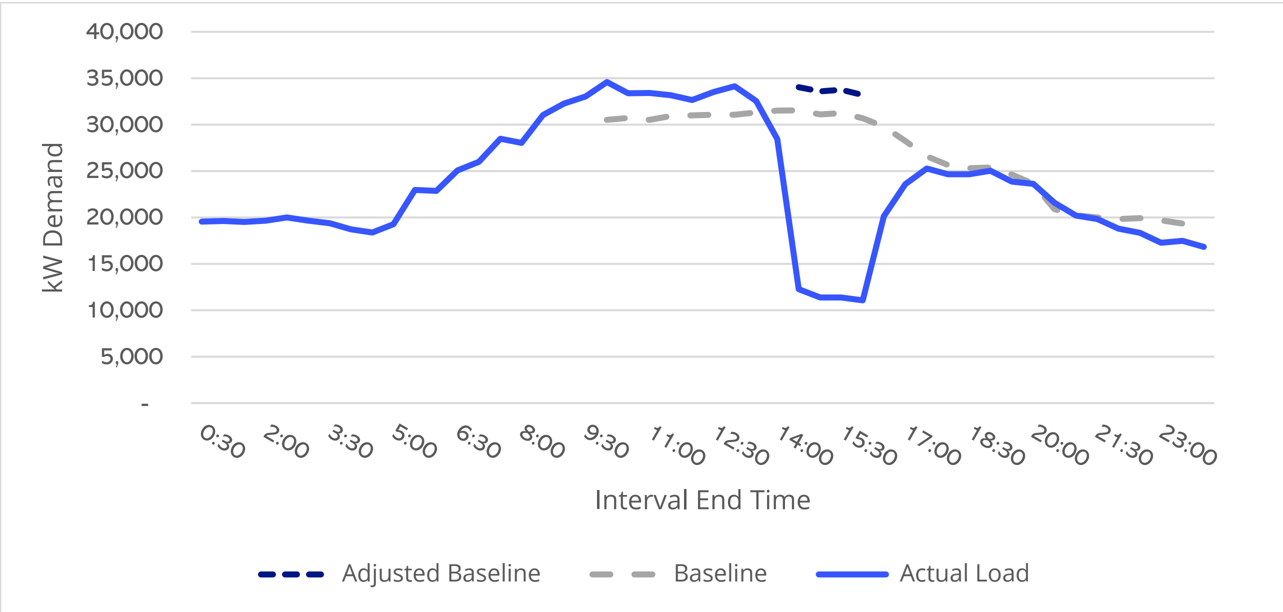


Figure 19 – Results of AEMO test 4 December 2019

This was again a successful test with around 22MW delivered and no notable variances from expectation in terms of participant performance.

6.9. Event Results

There were two real activations of the AGL NSW RERT portfolio by AEMO during the trial, on 23 January 2020 and 31 January 2020.

6.9.1. 23 January 2020 event

This activation occurred during the height of the 2019-20 bushfire crisis in NSW and Victoria. To provide some context, on this day:

- There were 70 fires burning in NSW, with 44 not contained.
- A Hercules C-130 air tanker crashed near Cooma while fighting the fires, killing three crew members.
- Homes were lost at Moruya and Bermagui on the NSW South Coast.
- There was a severe weather warning for damaging winds in parts of eastern NSW, including the ACT.
- Canberra airport was closed due to a fire in the Pialligo Forest.
- Melbourne was blanketed in brown rain, with play deferred at the Australian Open tennis.[4]

In Sydney, the maximum temperature reached a very hot 41.2 degrees, with 42.4 degrees in Penrith.

In this situation, many of our DR participants were already operating in emergency response mode before the declaration of the DR event. Examples of this included:

- Water utilities having to pump water to reservoirs for firefighting purposes.
- Telecommunications companies needing to restore critical communications in bushfire impacted regions.
- Water utilities with lower pump loads due to ongoing water restrictions.

Given this environment, and after detailed discussions with participants about which DR assets could still be used if an event were called, AGL's NSW RERT availability in the AEMO markets portal was revised downwards on 22 January from 20MW to 12MW.

AEMO issued an Invitation to Tender for short-notice RERT at 12:35pm AEDT, followed by an activation message at 3:30pm AEDT. The requested activation was 10MW for two hours from 15:30 NEM time to 17:30 NEM time. Ten to fifteen minutes before this event was due to finish, AEMO requested AGL to extend the activation by a further hour to 18:30 NEM time. There were some technical issues with AEMO's issuance of the extension message due to a configuration problem in their platform, and the message was not initially received by AGL. This was overcome by phone conversations on the day, however.

When the initial activation message was issued to participants, there were a several negative replies due to the emergency response environment already active on the day. These included:

- A telecommunications company that had received an instruction from NSW Emergency Services prohibiting the use of backup diesel generators except in cases where grid power was down. This

[4] Source – Guardian Australia https://www.theguardian.com/australia-news/live/2020/jan/23/nsw-fires-live-updates-victoria-bushfires-south-australia-fire-sa-australian-bushfire-near-me-cfa-rfs-latest-news-today-thursday

prohibition covered both urban and rural sites and prevented the backup generators being used for RERT.

- A water utility that had just been given permission to pump water from local catchments to townships that were in crisis due to water restrictions and had to take advantage of that pumping time.
- A water utility that had already curtailed load as it had received an earlier instruction to do so directly from the NSW Government under the State Emergency Response Request program, bypassing AEMO. AGL notified AEMO immediately we became aware of this – AEMO was unaware that this instruction had been issued.
- Some shopping centres declined to participate due to air quality issues from bushfire smoke.

Analysis of the event afterwards showed the expected underperformance from these loads. In the case of the shopping centres, this was also exacerbated by the long three-hour event in heat-wave conditions, and the fact that the event occurred on a Thursday evening, with a previously identified baseline problem emerging whereby shopping centres are penalised due to different closing times on different days of the week. There were also questions about whether the event messaging SMSs had been received at all the sites, possibly because of issues in the SMS network caused by the bushfire emergency. The shopping centre portfolio actually contributed a significant negative DR result during this event, which worsened as the event went on.

AGL had previously identified that a shopping centre that closes around 5:30pm on Monday, Tuesday and Wednesday will baseline poorly under the AEMO RERT baseline for an event on Thursday evening when it closes much later, despite clearly shedding load during the event. Likewise, on a one-off extremely hot day, the significantly increased load from the shopping centre air conditioners later in the day may not be reflected correctly in the same-day adjustment in the baseline calculation, causing an under-measurement of demand response.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW	Interval 5 MW	Interval 6 MW
Portfolio	13.14	4.38	8.99	6.41	4.94	3.41	1.72	0.82

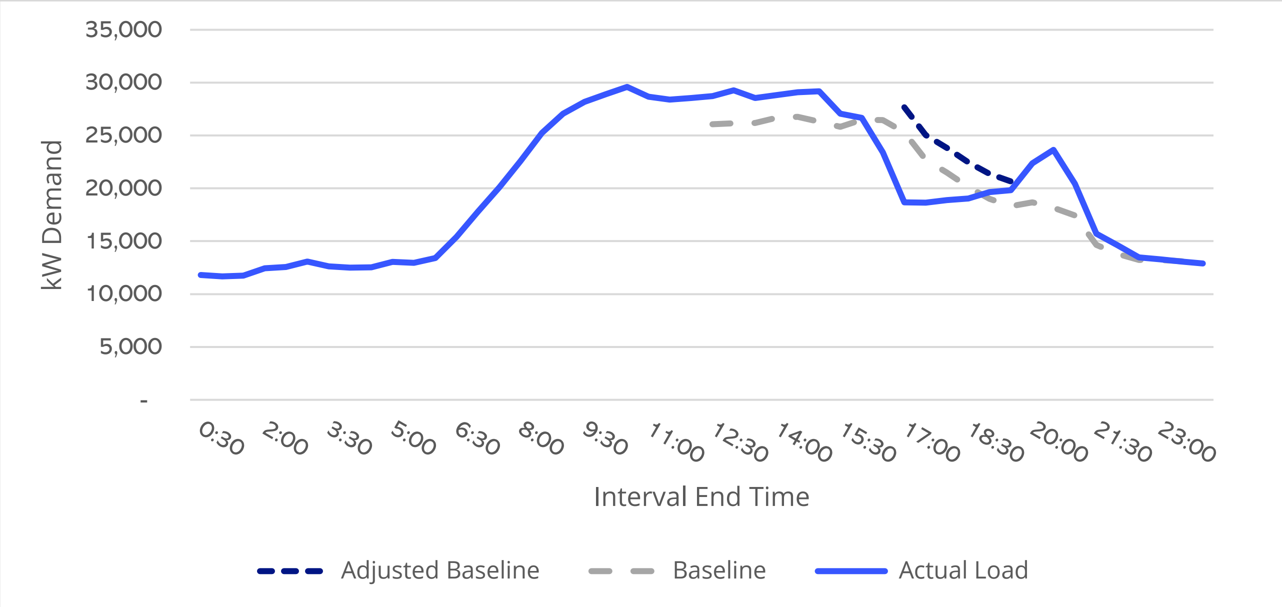


Figure 20 – Results of dispatch event 23 January 2020

Whilst the results show what was no doubt a useful demand reduction on the day, it was well below the expected performance of the portfolio under non-emergency conditions and it fades significantly towards the end of the event, mostly because of the shopping centres.

The result for the shopping centre component of the portfolio is shown in Figure 21. Other than the first interval, the contributed DR was negative throughout the event, worsening to a maximum of - 5.5MW as the event continued.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW	Interval 5 MW	Interval 6 MW
Shopping Centres	-9.57	-3.19	0.66	-1.61	-3.07	-4.27	-5.33	-5.53

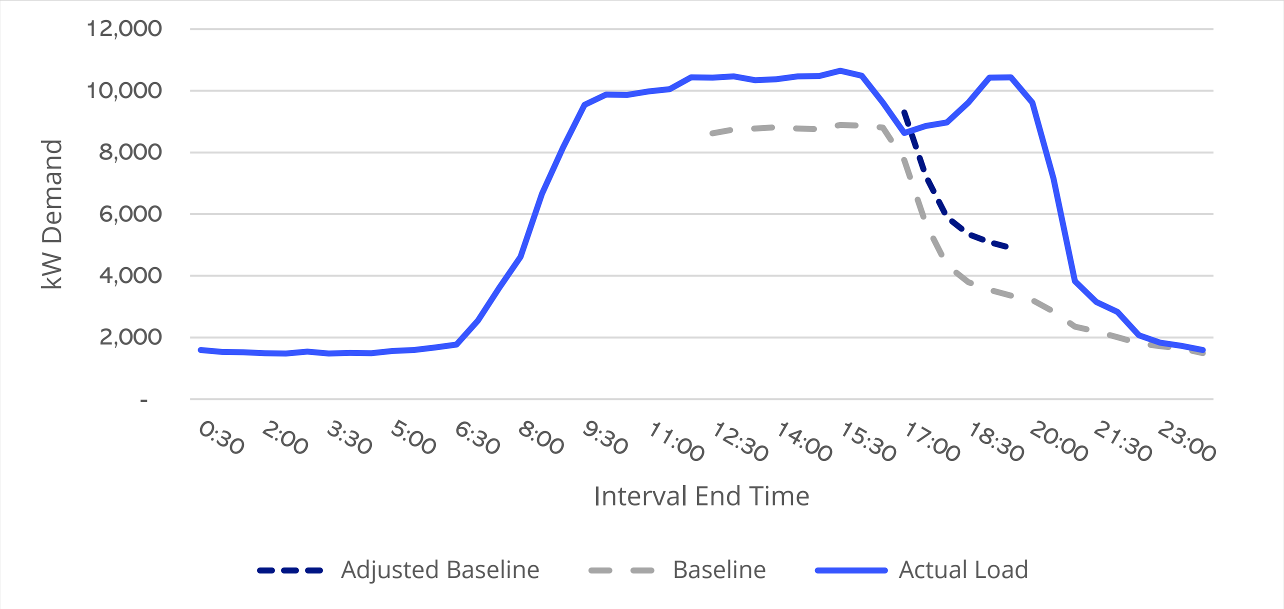


Figure 21 – Negative result for shopping centre portfolio 23 January 2020

Following this event, and after analysing the results and speaking further with participants, AGL further adjusted its NSW RERT availability to 10MW in the AEMO portal.

6.9.2. 31 January 2020 event

On 31 January 2020, destructive winds destroyed or severely damaged seven towers on the Victoria – South Australia transmission interconnector, separating the Victorian and South Australian power networks, islanding the Mortlake Power Station and Macarthur Wind Farm, and tripping the Portland Smelter. This resulted in a LOR2 lack-of-reserve condition in Victoria from 15:00 to 18:00 NEM time, plus frequency stability issues and other consequent problems across the NEM.[5]

[5] AEMO Final Report – Victoria and South Australia Separation Event on 31 January 2020 https://aemo.com.au/-

In moving to stabilise the Victoria/NSW/Qld part of the grid following this incident, AEMO issued an ITT for AGL's NSW RERT portfolio at 4:16pm AEDT, followed by an activation notice at 4:59pm AEDT. This notice was for 10MW of load reduction for the period 17:00 to 21:00 NEM time. At 8:29pm AEDT the event was shortened to finish at 19:30 NEM time, as AEMO judged that the reserve was no longer necessary.

Sydney weather on 31 January was hot with a maximum of 32.4 degrees, with 41.2 degrees in Penrith.

The same emergency conditions that existed for the 23 January event were still in place for this event, including the constraints on pumping and backup generator operation, leaving the declared 10MW as the maximum possible demand response available from the portfolio. However, bushfire conditions had abated slightly (54 fires burning with 28 not contained)[6] and the weather was marginally cooler along the coast. Accordingly, the result for this event was better and very close to the declared availability of 10MW.

	MWh	Average MW	Interval 1 MW	Interval 2 MW	Interval 3 MW	Interval 4 MW	Interval 5 MW
Portfolio	24.10	9.64	9.46	9.92	9.61	9.40	9.82

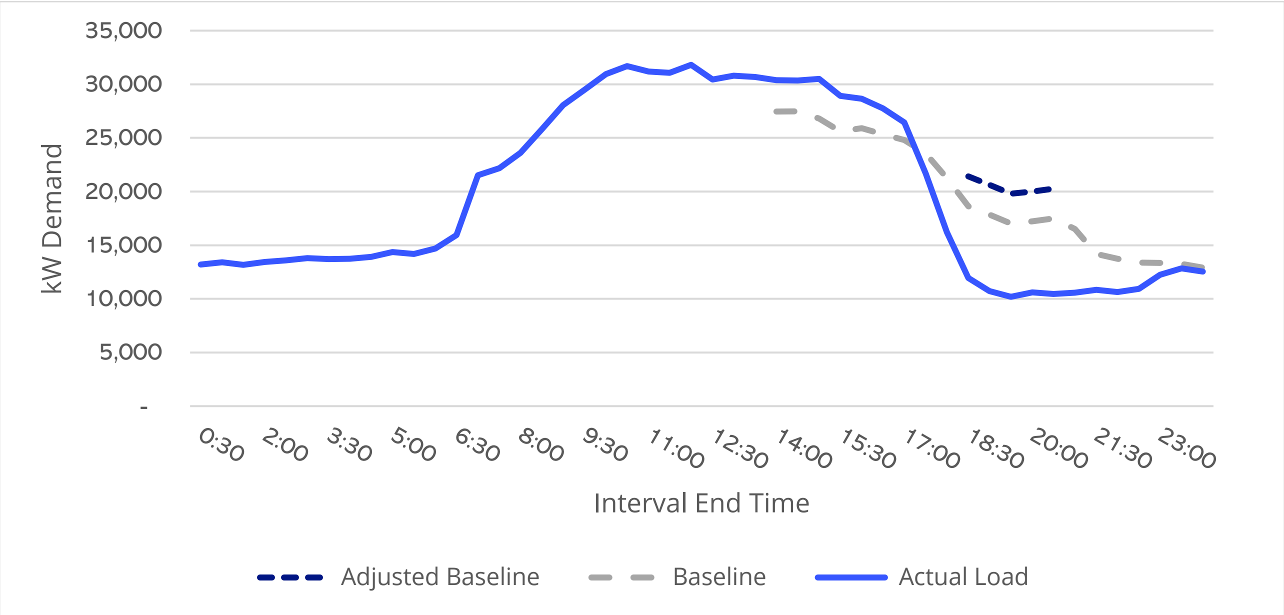


Figure 22 – Results of dispatch event 31 January 2020

/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2020/final-report-vic-sa-separation-31-jan--2020.pdf?la=en

[6] Source – Guardian Australia https://www.theguardian.com/australia-news/live/2020/jan/31/canberra-fires-live-updates-act-bushfires-nsw-australia-fire-near-me-heatwave-weather-forecast-latest-news

On 17 February 2020, after an easing of bushfire conditions and further analysis and discussion with portfolio participants regarding asset availability, the availability of AGL's NSW RERT portfolio was returned to 20MW in the AEMO portal.

6.10. Customer Research

In 2020 AGL was approached by a PhD student[7] from the University of Queensland who was studying demand response in the national electricity market and wished to research the customer impacts of demand response for C&I customers. With the permission of the participants, AGL provided a number of contacts from our portfolio for the student to interview.

This is a summary of the responses to four questions from interviews with six businesses participating in the AGL demand response program. The data was collected as part of a larger study to uncover the motivations, risks and opportunities identified by businesses when deciding to participate in demand response programs, ideally to understand how they overcame these risks, to implement and sustain improved energy use practices.

Responses from the business are aggregated and anonymous.

6.10.1. Customer motivations for participating

The main benefit identified by all businesses for participating in the demand response program was the perceived financial benefit, which was seen as a way to reduce electricity costs or as a source of funding for other energy or greenhouse gas reduction projects. Secondary motivations were the perceived social and community benefits. Businesses identified that their participation in the demand response program would help reduce stress on networks during peak demand times and avoid brownouts within their broader community. Participation in the program was also seen as a way to improve business resilience to unplanned electricity outages with back-up generators and batteries maintained for, and tested, during demand response events.

Some (n=2) businesses also commented that the demand response service provider was proactive in providing information and following up on questions and requests, which positively influenced their decision to participate in the program.

6.10.2. Perceived and actual challenges in participating

Businesses with large energy intensive plant and equipment and excess capacity found that their internal processes lent themselves to participating in demand response and only required minimal changes, therefore they didn't have many challenges to overcome.

"W*e have this excess capacity. We are going to shut down anyway. It's just a question of shutting down when they want us to".*

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[7] AGL acknowledges the contribution of Nicole Lashmar, PhD candidate at University of Queensland, for providing the data and authoring the findings regarding consumer experiences participating in demand response presented in section 6.10 of this report.

All businesses generally had a good understanding of their electricity use and costs, and therefore could calculate likely lost revenue from shutting down plant and equipment and compare this to likely DR revenues to understand the size of the financial benefits.

All businesses had the internal resources and capabilities to assess and put in place processes to participate, but some businesses did find it challenging to gain access to these resources due to other competing projects. Businesses have identified the larger electricity consuming sites and plant and equipment which could provide demand response for this program. Other smaller or remote sites, plant and equipment which consume smaller amounts of electricity or have larger perceived operational or safety risks were generally not included. Once plant and equipment were identified, the next challenge was identifying and assessing the hierarchy of risks for shutting down and starting up plant and equipment including safety, environment and operations, and putting in place procures and controls to mitigate these risks.

It was reported by all businesses that the voluntary nature of participation enabled them the opportunity to participate in the program whilst not compromising safety or operational risks or risking not meeting production targets.

Setting up clear communication channels and processes to enable operational personnel to make decisions to participate or not in the program overcame the challenge of being dependant on one person to be available at all times.

Initially, many businesses faced the challenge of engaging operations personnel to willingly participate in the demand response program, as this was viewed as an extra step above core business and anything that detracts from core business was not considered overly favourably. As the payments are made directly to the businesses and not to the operational areas participating in the program, the operational areas do not directly see the financial benefits of their additional work. However, some businesses chose to internally transfer the income, so there was direct financial reward for the efforts made to participate. Other businesses found that getting the right people on board and communicating the benefits largely overcame this initial resistance.

6.10.3. Lessons learnt from participating

New and novel energy management programs like demand response took longer than other energy management initiatives for some businesses to gain approval to participate and implement. This was due to perceived and actual potential operational, health, safety and environmental risks and therefore all levels of management and operations needing to be consulted and engaged in the decision-making process.

Having a central coordinating role was seen as critical to the success of the program by five of the interviewed businesses. Having this role to engage facility managers and operations teams early in the process to help identify opportunities, identify risks and develop processes, helped reduce the "push back" of individuals not wanting to participate. This was especially true when operations were "under the pump" to meet operational targets. Businesses with simpler shut down processes found that once operations teams overcame their initial reaction to shutting down due to a demand response notification, it soon became part of "business as usual" processes. One business also reported that communicating to operations teams about how the availability payments were paid for the business to prepare for a demand response event, so that if the event was cancelled after preparations were completed the business was still receiving the revenue and therefore their "time was not wasted", helped keep the teams engaged in the demand response process.

It is also worth noting that even though businesses had assessed the risks of shutting down plant and equipment for demand response, conditions on the day could change their ability to participate. Such conditions included weather and personnel availability and was reported as an issue for three businesses.

Using onsite generators for demand response proved to be more challenging than initially expected at two sites. This was attributed to remoteness and health and safety issues, which prompted businesses to consider moving to a "single button" approach for these assets. On the flip side, using the generators has improved the processes for start-up of these emergency response assets, which has strengthened the resilience of the sites in the case of an actual power failure.

The long notification periods and updates of upcoming DR events enabled better preparation and planning, for example, allowing tasks like maintenance and cleaning to be scheduled in advance of expected participation in a demand response opportunity. Generally, participants agreed that there had been adequate notification of events to enable them to plan ahead.

6.10.4. Overall perceptions about demand response

Having participated in the demand response program, all six of the businesses were overwhelmingly positive. All businesses agreed they would either actively seek out or consider participating in future programs if these were made available by demand response service providers. Gaining an extra source of revenue, in addition to the positive social benefits of helping to prevent outages, has made it sensible for businesses to continue in these programs.

Some (n=3) have realised there is an opportunity to add more load curtailment into DR programs and receive a lot more revenue. As a result of participating, many (n=4) have identified and contracted loads which are considered "low hanging fruit"; others discussed having "just scratched the surface" of what could be achieved with this program. However, increasing the amount of load reduction available for demand response will likely require automation of smaller, or more complex or remote processes. There was uncertainty expressed about the financial benefits being great enough to warrant the utilisation of internal resources and efforts required to make this happen.

It was recognised, that whilst demand response is still quite novel, and can add another layer of complexity – it is really "just another change management process".

The main aspects of the program which were reported as positive and helping businesses participate included the amount of notification provided by the demand response service provider and the reliable income provided by the availability payments. A small number (n= 2) of businesses did question the amount of compensation being provided for curtailing load versus the cost of electricity in the wholesale market for that same period but conceded that it still made sense to participate.

Finally, there was a suggestion made that there was an opportunity to recognise and showcase businesses that are providing demand response to improve reliability and prevent brownouts, whilst earning revenue. This recognition could raise awareness for other businesses and inform the broader community about their contribution to broader societal good.

6.11. Lessons Learnt from the C&I Program

6.11.1. Baselines

Whilst the current AEMO RERT baseline calculation works well for some DR participants, it does not work well for others. AGL's experience in the RERT program has demonstrated that the AEMO baseline works well for flat and/or highly predictable loads, but discounts DR sourced from temperature sensitive loads and intermittent or fluctuating loads, despite these loads being potentially valuable contributors in DR events.

One of these cases is air conditioning loads. High demand in the NEM on very hot days is often blamed on air conditioning, however, counterintuitively, air conditioning loads don't work well as a DR resource in the RERT program because they often don't baseline well, particularly in southern Australia where the prevailing weather patterns in summer comprise increasing temperatures over four or five days, culminating in a very hot day (usually the RERT event day) followed by a cool change. In this case the 10-day average used in the RERT baseline tends to discount the air conditioning load on the very hot day because the average air conditioning load on the previous ten days has been much lower. This discount is supposed to be compensated for by the same day adjustment factor in the baseline, but this doesn't happen because the adjustment factor is calculated too early in the day (between four hours and one hour before the start of the event), before the air conditioners are operating at full load. In the case of a RERT event at 4:00pm, the adjustment factor is calculated between midday and 3:00pm, when the air conditioners have a lower average load than during the event time.

Likewise, loads that are intermittent in nature are disadvantaged by the averaging effect of the baseline calculation. Some industrial processes fall into this category – AGL had a metal recycling business in the portfolio for which a 4MW load typically baselined at 2 – 3MW because the load fluctuates randomly throughout the day depending upon the rate that that material is fed into the plant. Despite this, using this load in a DR event actually removes 4MW of instantaneous demand from the grid. Some pumping loads also exhibit the same effect.

AGL discussed these issues in detail with AEMO and provided research and supporting data to ARENA and Oakley Greenwood for the purposes of a broader baseline methodology study. Some of this work has since been taken up in the design of the NEM Wholesale Demand Response Mechanism, which allows the possibility of more than one baseline being available for use by DR participants, subject to AEMO's approval.

During the ARENA trial, AGL altered its approach to recruiting customers to include a detailed baseline review prior to sign-up to ensure that the customer load profile was compatible with the AEMO baseline. Regrettably, this meant that some potential participants had to be advised that they were not suitable for inclusion in the program.

6.11.2. Timing of DR events

AGL's experience in RERT programs suggests that the most likely time of day for a RERT event is late afternoon through to mid-evening, around 4:30pm to 7:30pm.

This has consequences for the type of loads that can participate in RERT events. As usual, comparatively flat loads that run for extended periods can be expected to benchmark well, however the following loads have been found to be ineffective at these times:

- Industrial loads that run on a single shift basis – these have generally finished work for the day by 4:30pm.
- Commercial loads – most office buildings and other commercial sites have loads that decline significantly between 4:30pm and 5:30pm. Building management systems are often programmed to ramp down air conditioner compressors after 4:30pm and run recirculated air after this time.
- Shopping centre loads – on days when there is no late-night shopping, generally every day except Thursday and in some cases Friday. Shopping centres also turn off air conditioning compressors around 4:30pm on these days and have very little load after that time.

Aggregators assembling a portfolio of DR loads to participate in RERT should be cognisant of this and consider the time that events are most likely to occur when contracting loads, particularly if they are paying an availability fee to the participant.

6.11.3. Technology and automation

Whilst there is often a utopian vision of DR portfolios operating instantly at the push of a button in a darkened control room, AGL's experience during this project was that this vision is some distance from reality.

None of the DR participants in the portfolio would allow AGL to directly control their loads for a range of reasons that included:

- Site operational complexity – many sites did not have single-point control and DR dispatch required a series of manual tasks to be undertaken in sequence by technicians on site.
- Potential OH&S risks to site personnel through unexpected operation of plant.
- Potential financial cost of plant stoppages at times when production was required.
- Potential effect on the participant's customers.
- Cybersecurity risks.

Based on this feedback from a broad range of participants, AGL rapidly came to the view that automation of DR loads was not going to be possible in this project. The technology implementation therefore focussed on site monitoring in order to improve the visibility of DR loads prior to events, and to confirm the expected load reduction during events.

In many cases the implementation of site monitoring using specific DR monitoring hardware was found to be problematic (see section 6.6), and this approach was discontinued in the third year of the project.

The use of 5-minute near-real-time data from site billing meters delivered via API from Meter Data Providers, while not widely available from all MDPs at the present time, has shown more promise for DR monitoring purposes and is still being trialled by AGL.

6.11.4. Over-contracting

Several below-target test results over the course of the program reinforce the view that, in order to be reliable, an aggregated C&I DR portfolio needs to be over-contracted to ensure that it will perform to target under all conditions. The amount of over contracting necessary depends on the type and size of the participant loads, but something in the order of 30% over-contracting would seem to be prudent with the mix of type and size of loads that AGL had in its portfolio. Another way of sizing this would be to use a methodology similar to the Lack of Reserve (LOR) calculation used by AEMO, where the portfolio would be sized so that the loss of the largest DR participant (or possibly the two largest participants) would be covered by additional DR held in reserve.

The additional cost of this over-contracting would ultimately need to be factored into the cost of running the program, reducing the amount that can be paid to the individual participants.

6.11.5. Critical services loads

The experience of the 2020/21 summer highlighted the potential risk of underperformance during emergency conditions in demand response portfolios that contain a significant percentage of critical infrastructure loads such as water utilities and telecommunications providers.

AGL has several critical services providers in its DR portfolio, in particular a major telecommunications provider and several water utilities. During the portfolio activation events on 23 and 31 January 2020 (refer sections 6.9.1 and 6.9.2), many of these critical services loads were unavailable for DR because of catastrophic conditions caused by the NSW bushfires.

The coincident number of participant loads that were not available for DR at this time was considerably larger than would be normally expected if caused by random unrelated availability issues, whilst, at the same time, the likelihood of a DR event is higher when catastrophic conditions exist.

In accepting critical services loads into DR portfolios, DR providers will need to be mindful of the potential for this double-edged effect and compensate for it in portfolio makeup and availability calculations.

6.11.6. Summer vs winter

A test undertaken on the portfolio during winter demonstrated quite a variance to the results seen over summer (refer section 6.8.3.). Temperature dependent loads will perform differently, and this may also apply to other seasonal loads such as pumping. DR providers may need to modify the structure of their portfolio across the seasons to ensure that the required performance is achieved.

6.11.7. Training of site personnel

Throughout the program, AGL found that the best and most consistent results were achieved with participant companies and sites that had a low personnel turnover. Where particular personnel had been part of the program from the beginning, they tended to better understand the reasons for the program and how it worked, and became well practiced in executing dispatches.

New personnel being hired by a DR participant should be trained in the operation of the DR program as a matter of course (and AGL offered this to participant companies), but in practice training was variable. Some participants were extremely good at it and maintained a consistent performance across the program; others were not so good, and at during test activations it was not unusual to have a few responses from new site personnel who didn't know what the dispatch instruction they had just received was about. In some cases, site contact details had also changed without AGL being advised.

Fortunately, most of these issues were picked up during the six-monthly portfolio tests, however more frequent reinforcement of program procedures may be necessary with some participants to ensure optimum performance at all times.

6.12. C&I Demand Response – Beyond the Trial

Building upon the lessons learnt during the ARENA trial, AGL has undertaken further demand response activities both during and since the ARENA trial. These include:

- A long notice RERT contract with AEMO in Victoria during the 2017-18 summer.
- The Transgrid "Powering Sydney's Future" demand response project for transmission network support in the inner south area of Sydney. This is a four-year contract running from the 2018-19 summer through the 2021-22 summer.
- A short notice RERT contract with AEMO in NSW and Victoria in the 2020-21 summer. This contract also included residential behavioural demand response.
- Increased use of aggregated C&I demand response for wholesale portfolio management during the 2020-21 summer. Wholesale DR had previously only been undertaken with a small number of very large industrial loads.