NSW Demand Response

ARENA Knowledge Sharing Report

October 2019

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1. Executive Summary

This Knowledge Sharing report describes the second year of AGL's NSW Demand Response Project, co-funded by AGL, the Australian Renewable Energy Agency (ARENA) and the NSW Government. Details of the first year of the project have been detailed in AGL's ARENA Knowledge Sharing Report September 2018, published by ARENA at https://arena.gov.au/projects/agl-demand-response/.

During Year 2, the following elements of demand response (DR) were further explored:

- **Residential Behavioural Demand Response**

  Significant changes and improvements of the residential behavioural DR program were made in Year 2, including an increase in the size of the customer base from 750 to 3,500, the payment of financial rewards (bill credits) based on fixed load reduction targets, and the provision of near-real-time feedback to customers to allow them to monitor their performance against target during events. For the first time in a DR program, a deep learning algorithm was used to predict individual customer loads and set individual event targets.

  The second year of the program has provided further insights into the acceptance and effectiveness of behavioural demand response from residential customers, together with more clarity on the costs and practicalities of implementing a scaled program. The highest load reduction achieved for an event was 1.7MW and survey results indicate that the program was popular with customers.

  Some issues remain to be resolved regarding the application of forecasts (for target setting) and baselines. The increasing prevalence of behind-the-meter solar generation adds another variable that increases the uncertainty of load forecasts and baselines and can leave some participants confused about their results. The relatively small percentage of customers in NSW with a smart meter has also been identified as an issue that impacts the widespread adoption of residential DR.

- **Residential Controlled Load Demand Response**

  The residential controlled load program commenced in Year 1 with the installation of equipment in homes to directly control air conditioning loads and electric vehicle (EV) chargers.

  For the air conditioning program, equipment conforming to Australian Standard AS4755 "Demand Response Capabilities and Supporting Technologies for Electrical Products" was installed in 45 customer homes to provide DR capability to existing (already installed) air conditioners. Significant issues were encountered during the installation process with cost, timeframe and the level of customer inconvenience being higher than expected. The performance of the system was also poor, with considerable variability noted in how different air conditioner makes and models respond to DR commands and uncertainty about the level of DR that can be achieved without impacting customer comfort. Although customer survey results indicated many customers understood the intention of the program and were pleased to be involved, the air conditioning program was discontinued after two DR events due to the unpredictable performance of the air conditioners and the inconvenience being experienced by some participants.

The EV program aimed to test the potential of home EV charging load to be deferred from peak periods into other times of the day. Smart EV chargers that enabled deferred charging for vehicles during a DR event were installed in 14 homes. The program was well supported by the customers involved and successful in shifting significant load away from peak periods with no inconvenience to participants. Although the number of participants in the trial was necessarily small, the program successfully demonstrated the potential for home EV charging to be coordinated with energy system needs.

- **Commercial and Industrial Demand Response**

  The commercial and industrial (C&I) program continued into Year 2 with minimal changes from Year 1. The recruitment of additional participants became more difficult throughout the year for a number of reasons including incompatibility of loads with the AEMO baseline, operating hours that did not extend into the late afternoon/evening when RERT events are likely, commercial/site issues, or that the site was already participating in a DR program.

  The portfolio was tested twice by AEMO, in November 2018 and May 2019. Performance in the first test was below target and was illustrative of the variability that can occur in a DR portfolio. Between the first and second test, new loads were added to the portfolio and maintenance on a large site that couldn't participate in the first test was completed. The result from the second test was well above target.

2. Residential DR - Behavioural

2.1. Program Overview

This section describes the second year of AGL's "Peak Energy Rewards" behavioural demand response program.

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. These customers were incentivised by payments for signing up for the program, together with payments based upon their kWh load reduction during an event. Please refer to AGL's first Knowledge Sharing Report at https://arena.gov.au/projects/agl-demand-response/ for further details.

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 this feedback made a significant difference to the DR performance of the portfolio and to customer satisfaction with the program.

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

Following customer research and testing, the Year 2 program was designed to reward customers with fixed dollar amounts based upon achieving discrete 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 would be the same as 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.

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

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. The percentage reduction for the second (more difficult) target was varied during the program to understand if, and to what extent, target level influenced behaviour.

All DR programs require interval meters, or "smart meters", to be installed at the customer premises in order 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 adequate for a program that is aiming to provide real-time feedback to customers during an event.

In order to provide this feedback, AGL contracted a Meter Data Provider (MDP) to provide an additional 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 the customers via a mobile-friendly web portal for display on smart phones.

Parameter	Detail
Period	1 Dec - 30 Jun 2019
Participants	3,500 NSW residential customers
Number of Events	6 x 2 hours
Target design	Fixed
Target 1	15% reduction on baseline
Target 2	30/40% reduction on baseline
Incentives	$20 max per event
Event registration	$10
Target 1	$5
Target 2	$5
Baseline methodology	Deep Learning algorithm
Event monitoring	Online portal

Year 2 Behavioural Program Summary

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 or not seen the SMS, or to wait until they knew what they were doing on the day before deciding whether to participate.

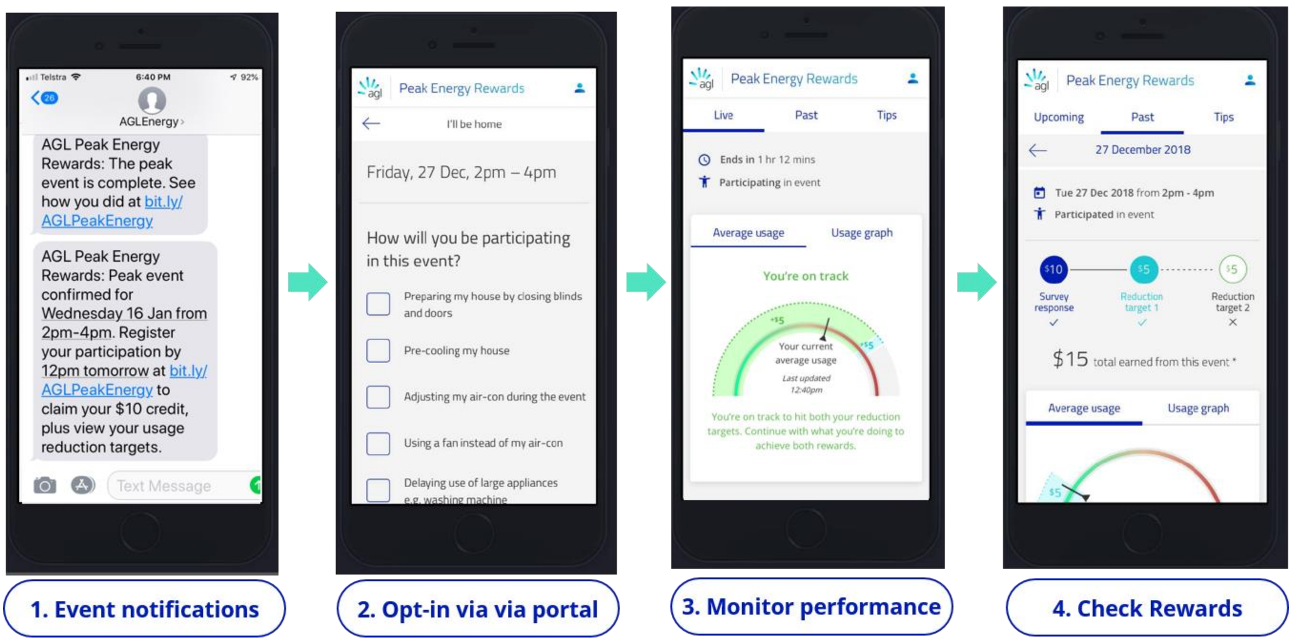
The first SMS contained a link to a survey in the web portal that asked the customer if they were going to participate in the event and, if so, how they planned to participate. Once the survey was complete, the customer was taken to the event page which showed a graphic of their current usage and the 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, eg, pre-cool house before turning off air conditioner, defer use of major appliances such as washing machines and dryers. All communications 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 that alerted customers to this. The portal showed which targets they had achieved and what their financial reward would be.

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



Customer Event Experience

2.2. Recruitment

Recruitment for the program was initiated by an Electronic Direct Mail (EDM) marketing message. Customers were selected to receive the EDM based on the following criteria:

- AGL residential customers in NSW for whom an email address is 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 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 time 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.
- Ensuring 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 due to access problems, most commonly at apartments and multi-unit dwellings. Around 800 meter installations did not proceed because of access or technical issues, and we achieved a final total of just over 3,500 participants in the program prior to the commencement of summer events.

2.3. Event Results

Five two-hour events were conducted between January and March 2019 in the period covered by this report. A sixth event was held in late July to establish portfolio performance during winter – not included in this reporting period.

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 issues. As it happened, no supply problems occurred on any of these days, however the total demand in NSW at the time of the 31 January event was very high.

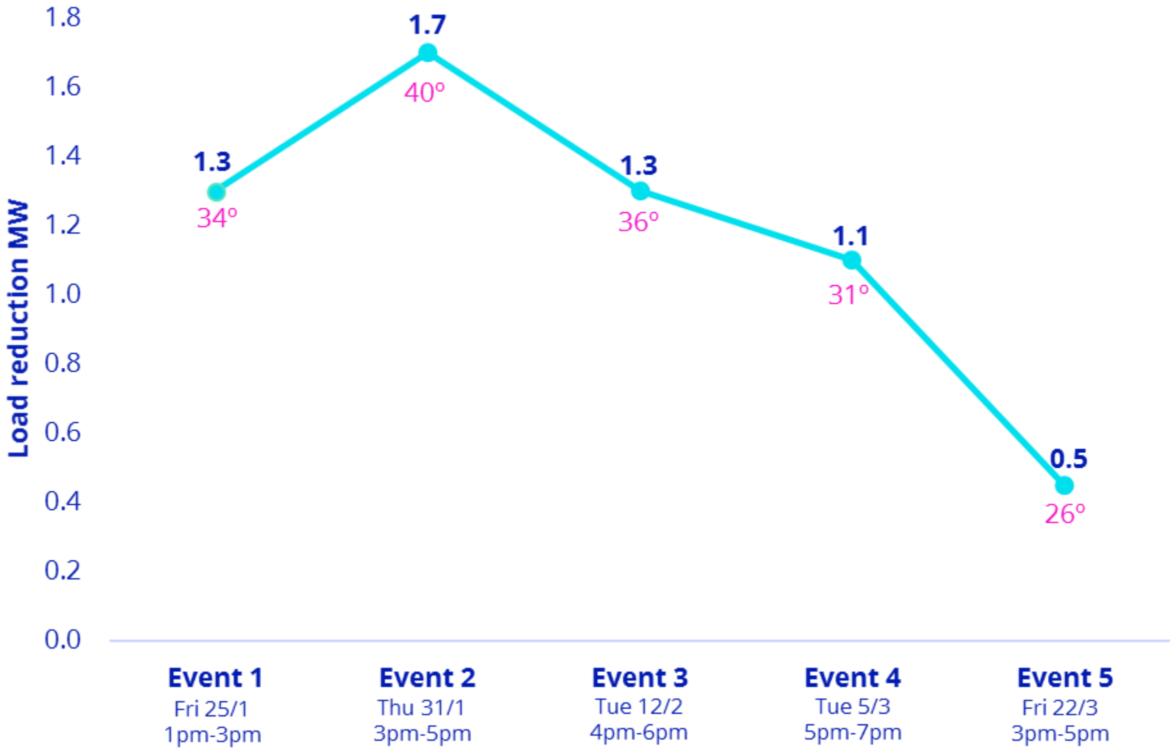
A significant constraint over event day selection was the preparation time necessary for the deep learning algorithm to calculate the individual load forecasts and target setting, which required a considerable amount of computing power and manual work on the part of the data analytics team. This had 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 in 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 as follows:

- It allowed a direct comparison between Year 1 and Year 2 results.
- 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.

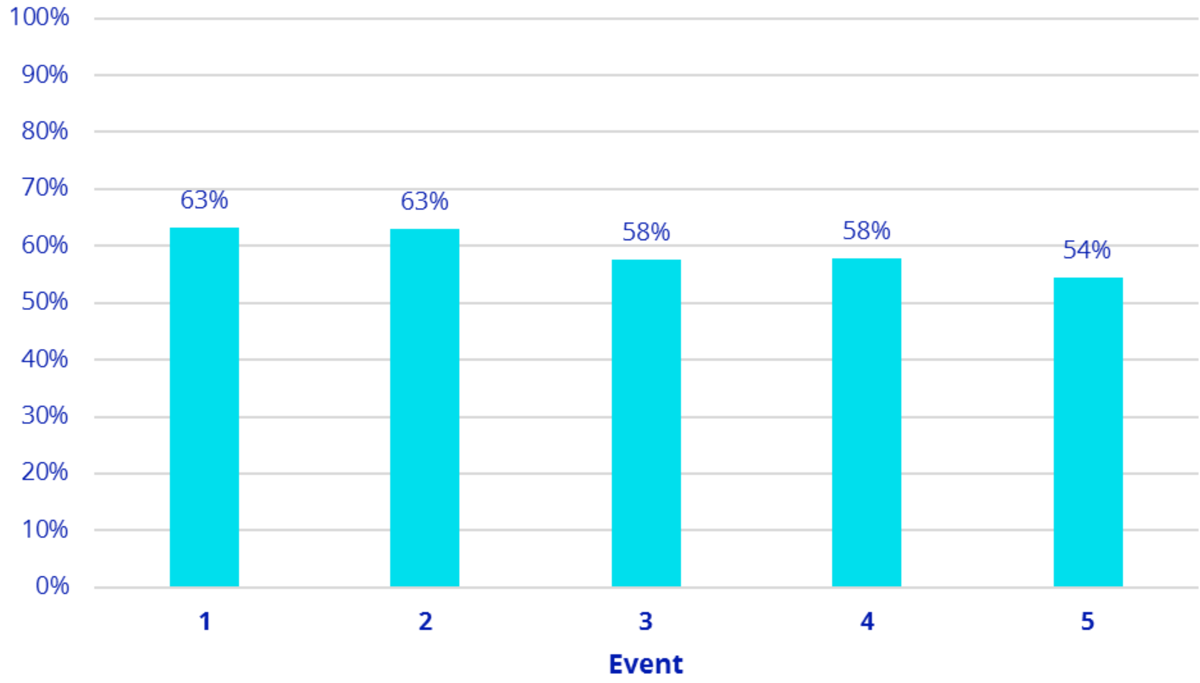
Graph 1 shows the overall load reduction per event across those customers that indicated that they would participate by marking "yes" in the pre-event survey, and who actually reduced their load, together with the corresponding maximum temperature on event day. Customers that didn't respond to the survey, 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.



Graph 1 – Per event average load reduction (for customers that reduced load)

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.

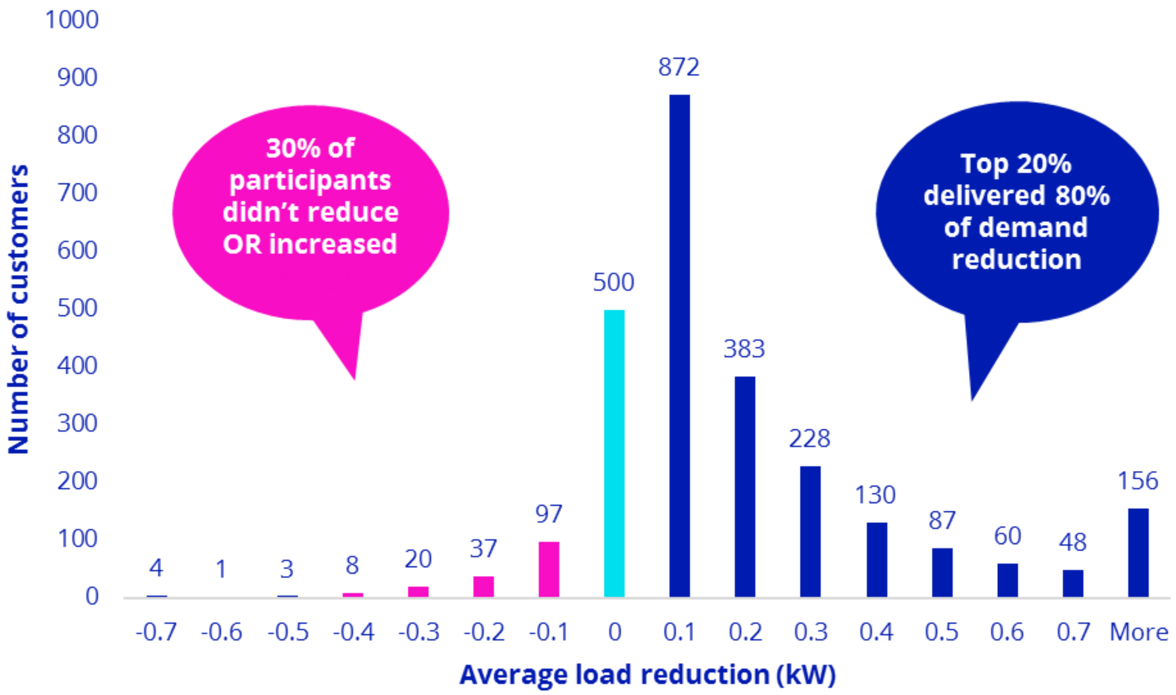
The percentage of customers registered in the program who participated in the events is shown on Graph 2. Around 60% of registrants actively participated, although the participation rate dropped from 63% at the beginning of the program to 54% at the end. This may also partly explain the lower total load reduction toward the end of the program.



Graph 2 – Event participation rate

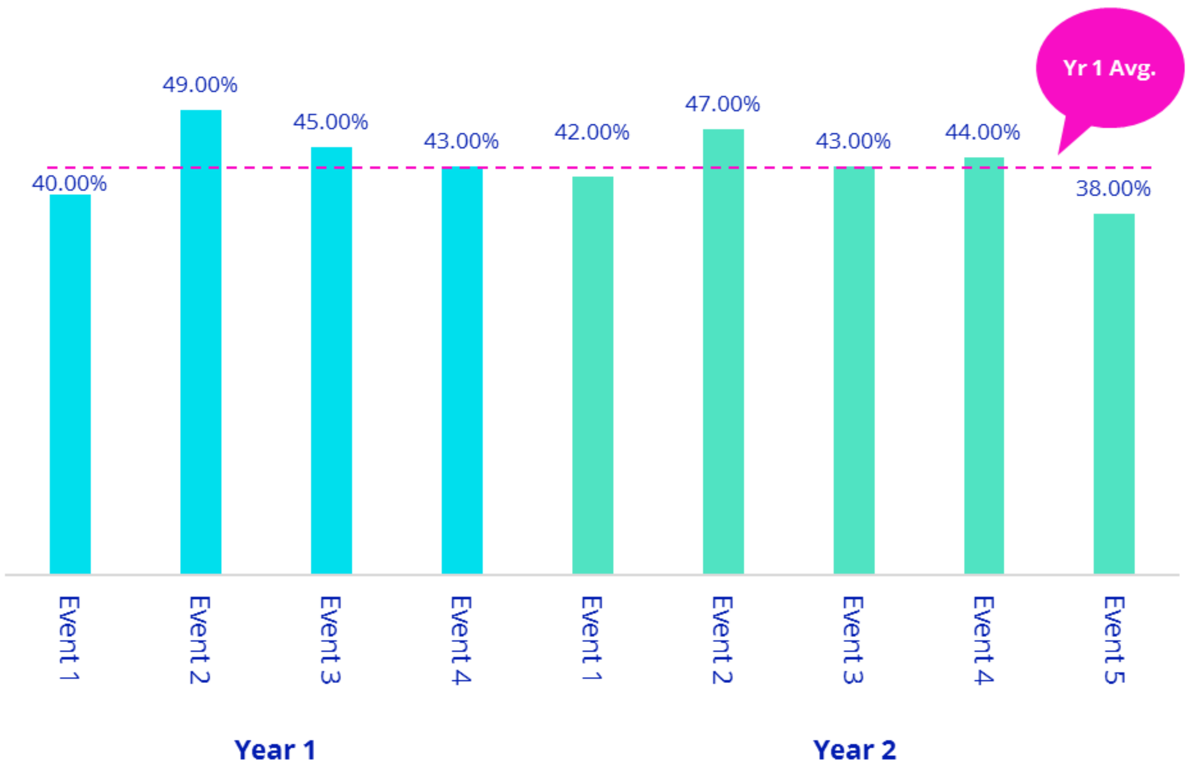
Graph 3 shows the average load reduction, across all five events, of participants that indicated in the pre-event survey that they would participate. There are several findings from this data:

- 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.



Graph 3 – Average demand reduction histogram across all events

Across the summer, the percentage load reduction performance of the actively participating Year 2 cohort was very similar to that of Year 1. This is illustrated in Graph 4.



Graph 4 – Percentage load reduction of participants across Year 1 and Year 2

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.

At present this is an unresolved issue. The increasing prevalence of solar across residential customers will make this more problematic with time.

2.4. Survey Results

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%

Are **highly satisfied** with Peak Energy Rewards

96%

Would **sign up** for next year's program

92%

Would **recommend** Peak Energy Rewards to family and friends

90%

Said Peak Energy Rewards 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 is innovative** in bringing something new to customers

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

- 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 in either Year 1 or Year 2).
- 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.

2.5. Conclusions

The second year of the residential behavioural program has 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 the 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, but it's not clear if this was due to their use of the portal or because they were the more engaged customers who would have performed well anyway. AGL is currently refining its approach for Year 3 in the light of these results.

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. However, based on the incentive structure used in Year 2, the cost of incentive payments for residential DR is already high compared to wholesale market spot prices. This will need to be addressed in future programs.

3. Residential DR – Controlled Load

The "Peak Energy Rewards Managed For You" program was designed to trial the control of large residential loads whose use would ordinarily coincide with peak demand periods. It comprised two elements:

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

In both cases the necessary infrastructure had been installed in customer homes leading up to the 2018/19 summer, although the installation phase for the air conditioner program took much longer than expected and the costs were significantly higher than expected.

Please refer to AGL's September 2018 Knowledge Sharing Report at https://arena.gov.au/projects/agl-demand-response/ for further details of the customer recruitment and installation process.

3.1. Managed For You – Air Conditioner Program

Demand Response Enabling Devices (DREDs) were installed in 45 houses in the greater Sydney area during 2018. These houses were selected from initial expressions of interest from 123 households, the final number of participants being much lower than the number of expressions of interest primarily due to the incompatibility of air conditioners with Australian Standard AS4755 "Demand Response Capabilities and Supporting Technologies for Electrical Products".

Whilst only AS4755 compatible air conditioners were selected for the trial, it was found during installation that many models required supplementary hardware units to be added, in addition to the DRED, in order to access the demand management functionality. This significantly increased the cost and complexity of the installation.

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, 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.

Events were remotely triggered via an internet API, and air conditioner load data was collected every 15 minutes using a separate monitoring device installed in each home specifically for the purpose.

Following the departure of two customers from the program, the trial proceeded with a total of 43 customers across the 2018/19 summer.

Customers were paid a sign-up incentive of $300 to be enrolled in the program and a further $100 by gift card at the end of the program. The final payment was increased from the initially proposed $60 ($30 x two events) to $100 in recognition of the fact that some customers had experienced significant inconvenience during equipment installation and during the test events that was not foreshadowed at the time of sign-up.

3.1.1. Event Communications

SMS messages were used to communicate with participants before and during events:

- A message the day before, noting the start and end time of the event and that the air conditioner's power would be reduced. An opt-out email address was included for the customer to use if they didn't want to participate in the event.
- A message at start of the event noting the air conditioner's power had been reduced and giving the event finish time. The opt-out email address was again included in this message.
- A message at the conclusion of the event, including a link to a survey to for the customer to provide feedback on the event.

As the program was directly controlling air conditioners, it was not necessary for the customer to do anything in response to the messages unless they wanted to opt-out. The opt-out capability was necessary to allow a customer to temporarily remove themselves from the program, for example for special occasions, for health reasons or if they no longer wished to participate.

Unfortunately, the air-conditioner control mechanism specified in AS4755 does not allow any opt-out or override capability at the customer's air conditioner. This is a significant shortcoming of the current standard when it comes to air conditioning control.

Event baselines were generated by averaging air conditioner load data from the days over the previous month that had a similar temperature profile to that of the test day.

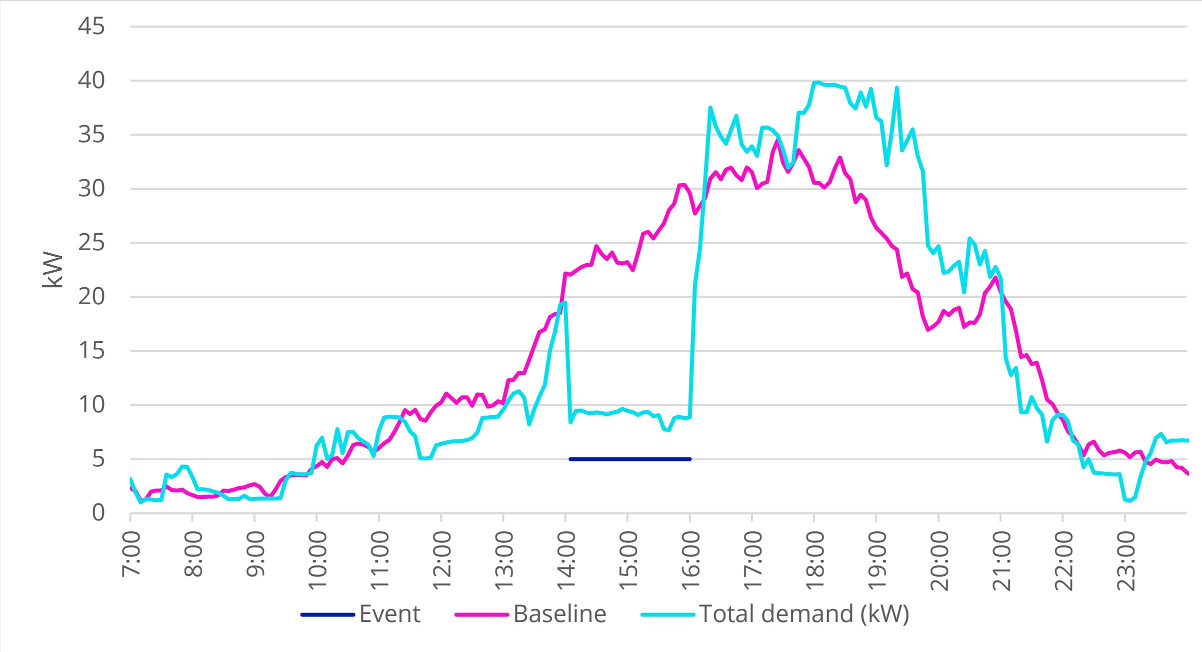
3.1.2. Event Results

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), 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.

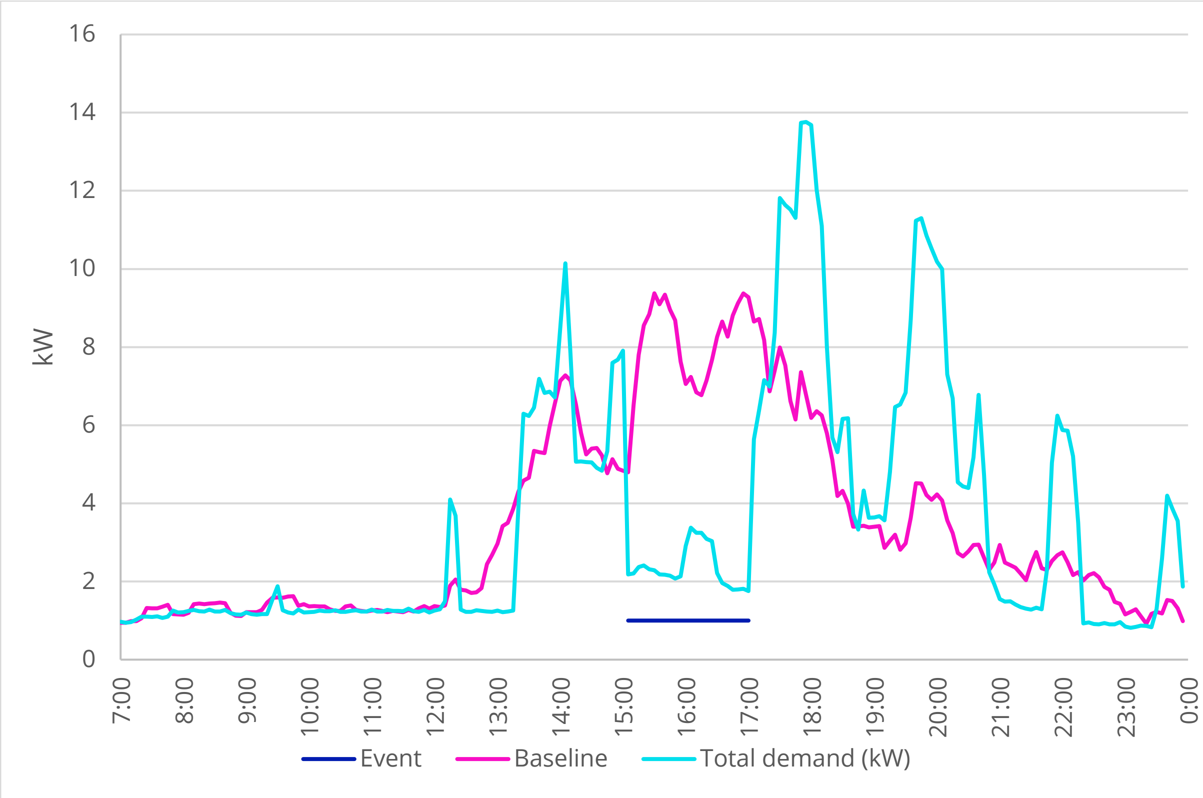


Graph 5 – Air conditioner program – Event 1 results

For the second event, the weather was slightly cooler and only seven houses had their air conditioners running and able to be controlled during the event. The command mode was again 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.



Graph 6 – Air conditioner program – Event 2 results

3.1.3. Performance Analysis

The modest participation rates reflect the likelihood of people being home at the time of the events. 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 could be implemented to return the air conditioners to normal operation without causing a 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.

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 unexpected ways and some customers were being inconvenienced, a decision was made not to conduct any further events.

3.1.4. 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 those 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 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 capability would be on the air conditioner itself.
- 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 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 is questionable.

AGL's conclusion from this trial is that the remote control of existing (already installed) air conditioners during demand response events 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 the air conditioner 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 may 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.

3.2. Managed For You – Electric Vehicle Program

As detailed in AGL's September 2018 Knowledge Sharing Report, 24 customers initially registered an interest in the AGL 'Managed For You' electric vehicle program, with 14 proceeding through to installation.

AGL fitted the 14 customer premises with either single or three-phase "smart" charging stations. These chargers could be remotely controlled and monitored by AGL through a platform developed by Chargefox especially for the program. Customers received a Chargefox app for their phone, through which most of the event communications were managed.

A further charger was installed at AGL's Melbourne office for internal testing of the user experience and verification of system performance.

The objective of the trial was to confirm:

- The technical feasibility of remotely controlling the charging of a fleet of customer EVs.
- The willingness of customers to allow the control of their vehicle charging.
- Customer acceptance of being automatically opted-in to an event, provided they were given the ability to opt-out.
- The size and shape of the load reduction achieved.
- Insights into how vehicle charging control could be implemented in the energy supply system.

3.2.1. Event Communications

During the test events, communications with the participants consisted of:

- An SMS alert 24 hours before the start of the event, including an opt-out via email.
- A Chargefox app notification at the start of the event. This included an opt-out button to allow the customer to opt-out of the event and restore charging at any stage.
- A Chargefox app notification at the end of the event.
- An SMS message with a survey link sent five minutes after the end of the event.

A final email was sent at the conclusion of the program containing a link to a final survey.

3.2.2. Events

AGL undertook five test events between July 2018 and March 2019.

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

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

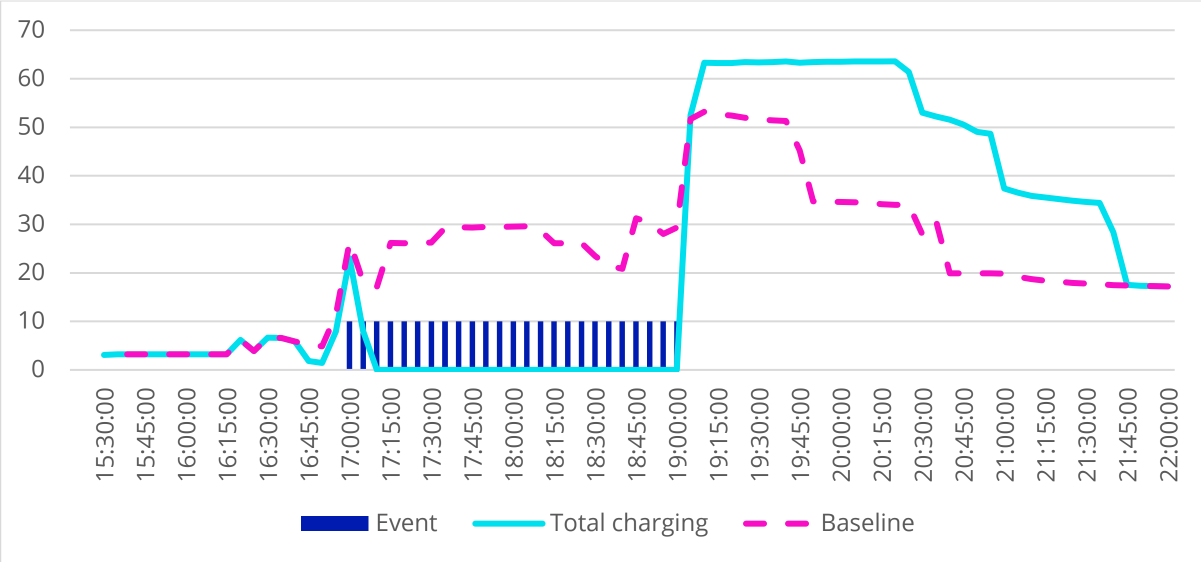
3.3. Performance Analysis

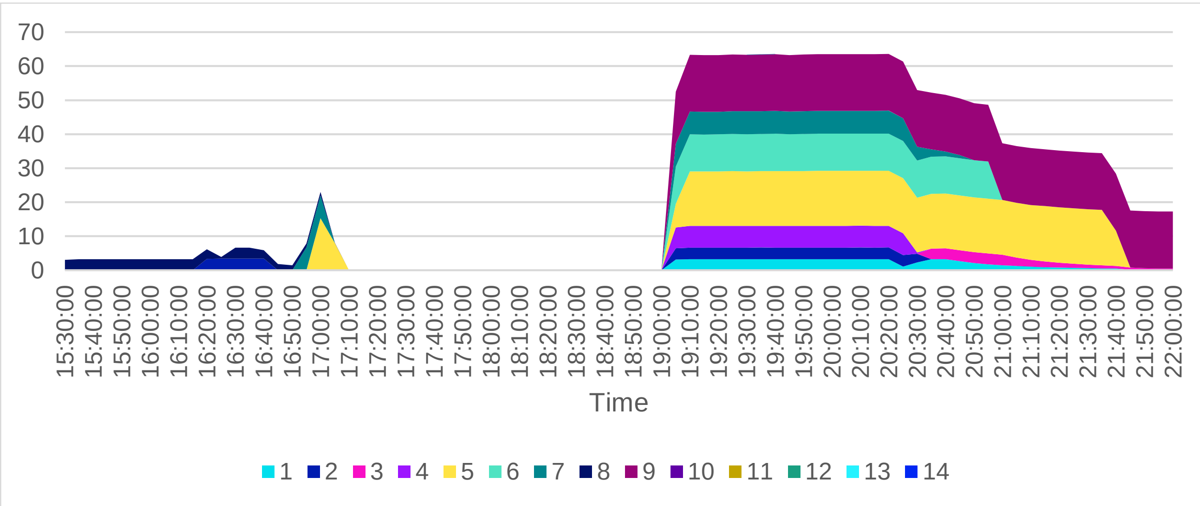
Analysis of charging data prior to program commencement suggested that the earliest time that worthwhile charging deferral could be achieved in the sample vehicle fleet during weekdays was 5:00pm. Earlier times were trialled in Events 2 & 5. The single vehicle present for Event 2 and zero vehicles present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





Graph 7 – Typical EV event graph, overall and per vehicle, Event 1, 24/07/2018 17:00-19:00

3.4. Survey Responses

There was a customer survey 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. All survey responses said that they would recommend the program to other electric vehicle owners. Overall satisfaction towards the program and AGL ranged from 90% to 100%.

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

3.5. Conclusion

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.

Nevertheless, 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.

Even more comprehensive charging control could be established with the aim of achieving a full vehicle charge by early morning (say, 5:00am or 6:00am), allowing more flexibility in the timing of charging and a much later charge commencement time after the evening peak. At scale, this could be coordinated to enable further integration of renewables into the grid and maximise the utilisation of existing network infrastructure.

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 would also appreciate feedback of DR results after the event.

4. Commercial & Industrial DR

4.1. Introduction

AGL began recruiting commercial and industrial customers in October 2017 in order to provide 17MW of demand response in NSW for the ARENA program. Details of the recruitment process, the DR activation processes employed, and the results of tests through to August 2018 are covered in our first Knowledge Sharing Report published by ARENA at https://arena.gov.au/projects/agl-demand-response/.

The portfolio itself, the technology used and the processes employed in the C&I DR program have not changed significantly since the period covered by the first report. This report will detail the minor changes that have taken place, together with our experiences during the second year of the program.

4.2. Portfolio

AGL started the period covered by this report with a nominal 17MW of C&I demand response. This had most recently been proven in an AEMO test held on 26 June 2018, for which the test result was 17.7MW.

The portfolio itself has not changed significantly since the previous report. Two new participant companies have been added and an existing participant company added a further site. A small number of individual sites have left the program, however the corporate entities themselves did not leave. Those sites that left did so for the following reasons:

(a) Several small sites owned by the one company were replaced by a single larger one able to be dispatched using fewer resources.

(b) A small number of sites were divested from their corporate parent and no longer available to participate.

It is encouraging that no companies have sought to leave the program to date, and this would tend to indicate that they see value being in the program. It should be noted, however, that the contracts AGL has with its DR participants do not bind the participants to a firm performance level and allow the participants to reduce their performance without penalty (other than the loss of availability payments). This means a company can remain in the program even if its contribution reduces below that originally contracted.

The portfolio currently comprises 34 sites across the following industry sectors:

- Data centres (1 site)
- Telecommunications (2 sites)
- Shopping centres (9 sites)
- Manufacturing and recycling plants (4 sites)

- Water utility pumping stations and treatment plants (17 sites)
- University campus (1 site)

Most of these sites are in metropolitan Sydney, with eleven water utility sites and two shopping centres in country NSW.

4.3. Recruitment

AGL has kept its recruitment process running during the second year of the program, with a telemarketer working three days a week contacting potential participants.

In the second year of the program we have noticed that the pool of suitable companies available to participate in DR has diminished, and the success rate of recruitment has dropped significantly. A possible reason for this is that most of the C&I loads in NSW suitable for the ARENA RERT project have been contracted to a DR program already. Others aren't able to participate for a range of operational or commercial reasons.

There are currently 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 are known to have C&I customers contracted with some form of wholesale market exposure or curtailment provision, making these loads unavailable for RERT. In addition, DR aggregators have contracted NSW C&I sites to provide Frequency Control Ancillary Services (FCAS).

During Year 2 we refocussed on assessing the suitability of loads to work effectively with the AEMO RERT baseline. Issues with this baseline were described in our first Knowledge Sharing Report and elsewhere and remain unresolved at the time of writing.

Another issue that excludes many loads from participating in the program is their operating hours. Experience in the RERT program in NSW and Victoria suggests that the most likely time that a RERT event is called is in the window of 4:00pm to 8:00pm, or possibly later. This excludes any site that runs on normal business hours, a single industry shift, or even shopping hours on most days. Loads need to be either a 24-hour process or at least a two-shift industrial operation.

4.4. Technology

In AGL's first Knowledge Sharing report, we detailed some of the issues encountered installing specific DR monitoring and control hardware in the field. These were:

- 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 the hardware and installation is not economic for many smaller sites (ie the cost is higher than the DR benefit that the site delivers to the program).

We have found on-site installation of specific DR monitoring hardware to be problematic, often requiring significant resources and time. In many cases these installations would be uneconomic if costed on a commercial basis.

To date we have not attempted to install remote control of customer loads at any site, as we currently have no participants in the portfolio who will allow the dispatch of their DR via remote control. The reasons that participants have given for not allowing this include:

- Operational complexity of the site/process – automation would be extremely difficult or impossible, and/or expensive with significant equipment upgrades required.
- Risk management – the participant wants to be fully in control of the risks relating to the site.
- Customer service – the value of the participant's customer experience is greater to the participant than the returns from DR.
- Safety – the participant does not wish to have any possibility of DR activity impinging upon safety at the site.
- The wish to override a dispatch for commercial reasons – the participant may have orders or production targets to meet, and resources employed to do that, with a value greater than the value of the DR.

In response to these experiences, AGL is altering its approach for the third year of the project. We are currently assessing a monitoring regime that will use near-real-time data sourced from Meter Data Providers that would be presented to AGL via an API. This is very similar to the technique used successfully in the residential behavioural program in Year 2 (refer section 2).

This approach has the advantage of requiring little or no installation work on site. Where installation work is required it can be completed by the Meter Provider without any need to move beyond the meter panel. This is expected to simplify the installation process enormously.

Our experiences with this new approach will be detailed in the next knowledge sharing report.

4.5. Tests

During the period covered by this report there were two AEMO tests of the C&I portfolio, on 20 November 2018 and 30 May 2019.

The result of the test on 20 November 2018 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.

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 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 (refer to our previous report for further details).

- 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, 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 on maintenance at the time of the test remained off-line for substantial periods over the next six months, 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 utilities added a further 0.5MW – 1MW of curtailable load.

The second AEMO test occurred on 20 May 2019. The result of this test was 20.9MW, well above target. Most of the issues identified in the previous test did not recur, although air conditioning loads remained low due to the cooler weather and one rural water utility still had a reduced DR performance due to water restrictions.

Since the May 2019 test, a further water utility has been added to the portfolio. These new participants should provide sufficient buffer for future events.

There were no activations of the portfolio during the period covered by this report.

4.6. Conclusion

The below-target test result in November 2018 reinforces the view that, in order to be reliable, a C&I DR portfolio needs to be over-subscribed to ensure that it performs to target under all conditions. AGL has concluded that ~30% over-subscription would generally be prudent, assuming a similar mix of the types and sizes of loads that exists in this portfolio. The additional cost of this would be borne by the DR provider and factored into the cost of running the program.

In selecting new loads for the portfolio during Year 2, AGL has also carried out a greater degree of due diligence regarding the performance of those loads against the AEMO baseline, and also to confirm that the loads operate and are able to respond in the evening timeframe when RERT events are likely. These factors have reduced the available pool of potential DR loads able to be used in the NSW RERT program.