ZEN ECOSYSTEMS™

ARENA/AEMO DR Trial

Project Performance Report

25 October 2018

ZEN ECOSYSTEMS™

REVISION HISTORY

VERSION	DATE	MODIFIED BY	COMMENTS
1	May 4th 2018	Bede Wolfenden	First Release
2	September 11th 2018	Sean Aucamp	-
3	October 10th 2018	Sean Aucamp	-

ZEN ECOSYSTEMS™

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1. SUMMARY

1.1 Executive Summary

Zen Ecosystems (ZE) ran multiple DR events in summer 2018, going a long way to meeting the DR Pilot Program objectives. ZE recruited over 1,400 program participants through our RACV partner campaign, along with smaller behavioural DR cohorts, commercial building HVAC and refrigeration loads. Multiple DR events were conducted and measured successfully through the AEMO RERT mechanism.

Throughout the testing events, ZE were faced with a number of challenges that may have influenced the results of the programme. These challenges included poor access to participant data; difficulty in ascertaining accurate baseline methodologies; unexpected behaviour of Frigbot and refrigeration loads; and results being affected by testing times and testing conditions.

There are some learnings that ZE will take away to improve the programme and work with ARENA and other authorities to have better access to available resources that can improve results. We hope to build participation and demonstrate the value of DR participation within the next 12-18 months.

1.2 Programme Summary

This report documents the performance, learnings and findings of the Planet Innovation (PI) Demand Response Programme (DR), run by Zen Ecosystems (ZE). The activities covered include knowledge sharing activities, test Reliability and Emergency Reserve Trader (RERT) events and documents challenges encountered through the programme's creation and execution.

The report includes:
- National Metering Identifier (NMI) and Data Stream Suffix Collection Issues (Nov 27th)
- PI DR Staff Trial (Nov)
- PI DR Learnings for Scale (for a large third-party DR programme) (Dec 13th)
- Test RERT Event (Feb 8th)
- Test Event Summary Report (Feb 13th)
- Test RERT Event (Feb 27th)
- ARENA DR Workshop (Mar 8th)

1.3 Programme Performance Summary Table

DR LOAD TYPE	AEMO ADJUSTED BASELINE PERFORMANCE (KW)	ZEN ECOSYSTEM'S ALTERNATIVE BASELINE PERFORMANCE (KW)
RACV Behavioral Programme	-4.09	27.9
PI Behavioral Programme	-2.93	7.59
Commercial Refrigeration	-21.98	0
Commercial Buildings	43.60	47.257
TOTAL	14.60	82.72

2. OVERVIEW OF DEMAND RESPONSE BEING PROVIDED

ZE's goal for providing DR was to target small to medium sized loads (typically HVAC&R and lighting) at scale, using the ZenHQ™ cloud platform to deliver DR signals manually or automatically.

ZenHQ™ is a centralised energy control system for multi-site businesses. ZenHQ™ combines our smart, connected, thermostats and lighting controls with the power of a cloud software solution to view and manage those devices for a simple and effective building energy management system. Lightweight and affordable, ZenHQ™ allows for complete control of HVAC, lighting, or both, depending on needs and energy efficiency goals

The PI DR load portfolio for 2017 / 18 summer involved a broad span of DR loads located in Victoria and have 3 primary categories:

- Behavioral Demand Response (±1,450 NMI's);
- Commercial Refrigeration NMI's (20) with remote / wireless control; and
- Commercial Building NMI's (5) with manual and ZenHQ™ controlled HVAC loads.

2.1 Behavioural DR Programmes

2.1.1 PI Behavioural DR Programme

The PI "*Save the Grid*" demand response programme was the forerunner to the larger RACV "*Help the Grid*" programme (see below) and provided the learnings and framework used for the RACV programme. It contained a total of 50 NMI's that covered a variety of ZE controlled residential HVAC loads as well as behavioural load controlled by PI staff, family and friends.

The incentive for participation in the programme was two movie tickets to Hoyts Cinemas per participated event.

2.1.2 RACV "*Help the Grid*" DR Programme

RACV partnered with ZE as a contributor to PI's DR load portfolio. The load was provided in the form of behavioural DR of members who enrolled in the RACV "*Help the Grid*" programme. This programme was launched on 30 January 2018 and the campaign was publicised and reported on through national and state print and radio media (Neill Mitchell, 3AW) as well as through RACV email and social channels. (https://www.theaustralian.com.au/business/mining-energy/insurers-turnitoff-answer-to-heavy-electricity-use-days/news-story/c2a6b9ac37167b6fd54a12cbec92fd08)

At the time of the first event on 8 February 2018, had ±1,300 NMI's / members enrolled to participate. This enrollment increased to ±1,400 NMIs by the second test event on 27 February 2018.

To incentivise enrolment and participation in the programme, members were offered the opportunity to win an all-inclusive weekend away for two at RACV's prestigious RACV Torquay Resort.

RACV

Become a member   My Membership   Discount tickets   Travel deals   RoyalAuto online

Help the Grid

Dear Timothy,

A reliable Victorian electricity grid is important to everyone and RACV members can now assist in times of peak demand by participating in **RACV's Help the Grid program**. By using less electricity during times of extreme demand together we can make a difference – helping balance supply and demand, and taking pressure off the electricity grid.

REGISTER HERE

Register now and you could win a weekend for two at **RACV Torquay Resort**

REGISTER NOW

*Terms and conditions apply.

2.2   Commercial Refrigeration Load

Frigbot specialises in retrofitted remote control of refrigeration loads. This technology allows remote, wireless control of large refrigeration devices such as cool rooms, refrigeration cabinets and chest freezers. The opportunity size is significant with 100,000's of such devices spread throughout hospitality establishments.

ZE utilised Frigbot's device to provide DR by triggering refrigeration defrost cycles remotely which is not noticeable by the customers and is part of the device's normal daily operation.

Currently, at least 30 devices are controlled by Frigbot devices. These devices include large refrigeration devices (on a total 20 establishments / NMI's) such as cool rooms in pubs and restaurants around the Mornington Peninsula. However, NMI's for only eight establishments were recovered by Frigbot for submission to AEMO.

2.3   Commercial Building Controlled HVAC Load

Two main building types encompassed the commercial building load:

- Medium size commercial office space; 2 floors, ±2,400m^2, 20 x control points, manually controlled HVAC load for non-critical areas of the building.

  During an event, the HVAC systems were turned off completely.

- Smaller commercial building; ±120m^2, < 5 x control points, provided HVAC load controlled remotely via ZenHQ™.

  During an event, the set-points of the AC systems were increased by 3ºC by ZE via ZenHQ™.

3.   PERFORMANCE ANALYSIS

Over the course of the summer, two RERT test events were requested and executed by ZE on 8 February 2018 and 27 February 2018.

8 February 2018

This event yielded a result of -6.603 kW (i.e. extra load was added to the grid) according to the AEMO adjusted baseline methodology. Initially the results received from AEMO provided no visibility on individual or even cohorts of NMI's. Due to data privacy and logistical difficulties, ZE was unable to obtain NMI specific data of event participants.

On appeal to AEMO, raw energy data was provided for large cohorts of NMI's for the event that enabled calculation of baselines and performance of those cohorts.

It should be noted the initial -6.603 kW result included the energy usage for all 1,400 RACV programme participants whether they participated in the event or not. This was suspected as the primary cause of the poor result. A later request cohort for RACV only contained ±120 participants who filled out a non-mandatory post event survey and confirmed participation, leading to a more positive result, although not the official result for this event.

For this reason, the 27 February 2018 event will be used as the benchmark for the PI DR performance with results from the 8 February 2018 event providing support.

27 February 2018

This event was more successful with a result of 14.6kW using the AEMO adjusted baseline methodology.

Learning from the previous difficulty, segregated cohorts of NMI's that had confirmed participation in the event were submitted to AEMO and a prompt reply of data was provided, excluding the commercial HVAC cohort, due to privacy concerns that it's number of NMI's was quite small (<5). However, as the total summary energy data for all segregated groups was provided, the final missing commercial load group energy usage could be calculated for the event period.

Please note that the summary data does not contain data necessary to calculate baselines. AEMO baseline data cannot be calculated for the commercial building cohort.

Due to the well-known issues of the AEMO baseline to correctly characterise varying loads, such as behavioral and temperature dependent HVAC, ZE proposed an alternative baseline for some of the cohorts (behavioral cohorts and the commercial) as its baseline data was not available.

Using the alternative baseline calculations, the total DR provided for the final event (28 February 2018) as determined by ZE is 82.72kW.

3.1   Behavioral DR Programme Performance

3.1.1 PI Behavioral DR Programme

Event Observations

The event execution appeared successful. Automated text messages were sent out, and from message replies, event participation was confirmed by 27 of 50 participants (54%). Movie ticket incentives were issued to confirmed participants after the event.
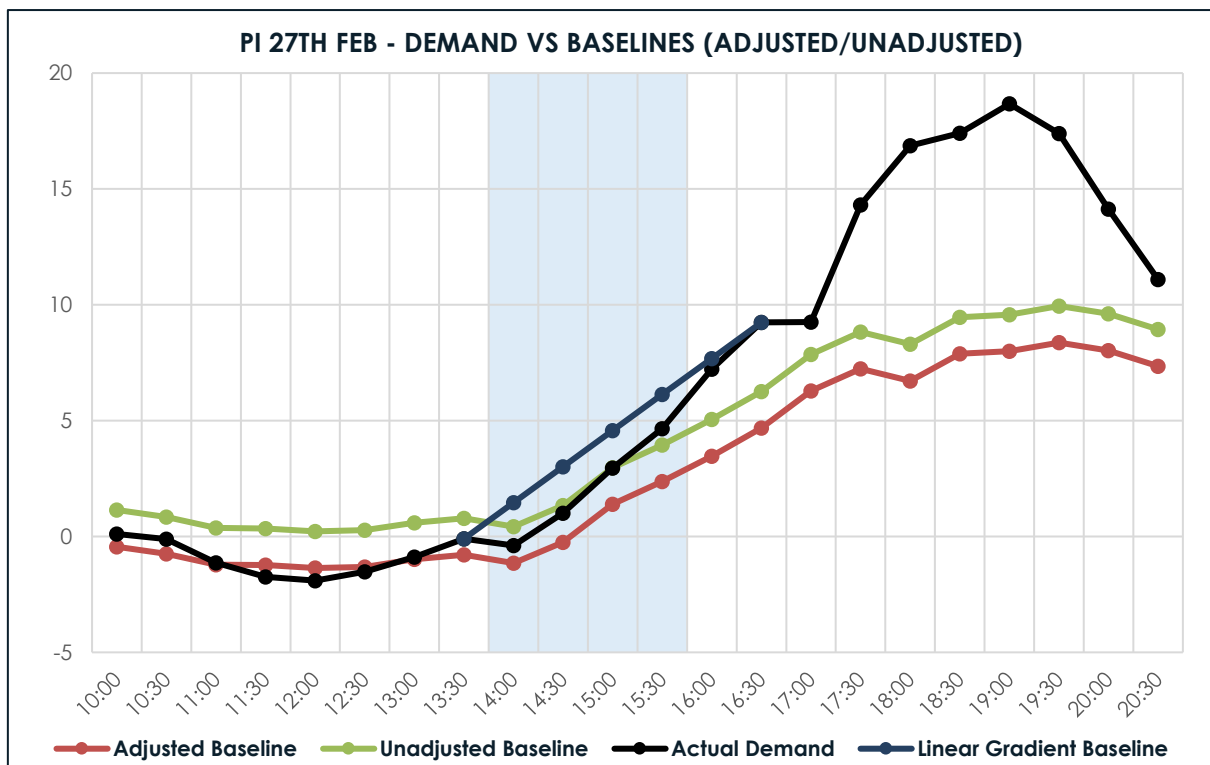
Event Data Analysis

Figure 1 - Energy demand of 27 YES participants who actively indicated event participation compared to AEMO baselines and Zen's Linear Baseline Methodology.

As shown with the RACV data, the adjusted baseline is lower than the unadjusted due to the lower morning energy consumption (relating to lower than normal morning temperatures) that produced a negative result of -2.93kW despite a visible DR response.

Alternative Baseline Analysis

As shown in Figure 1, energy begins to rise from midday, dips for the start of the event while continuing to rise (most likely caused by solar in the group diminishing).

Using a linear baseline methodology that will be discussed in more depth with the RACV results, ZE observed a DR delivery of 7.6kW (0.28kW/person) that is close in size to the RACV results on a per person level.

Considering the 8 February 2018 event, and using the adjusted baseline (which lines up suitably for this day) like in the RACV group, Figure 2 shows a noticeable dip during the event time and a DR delivery

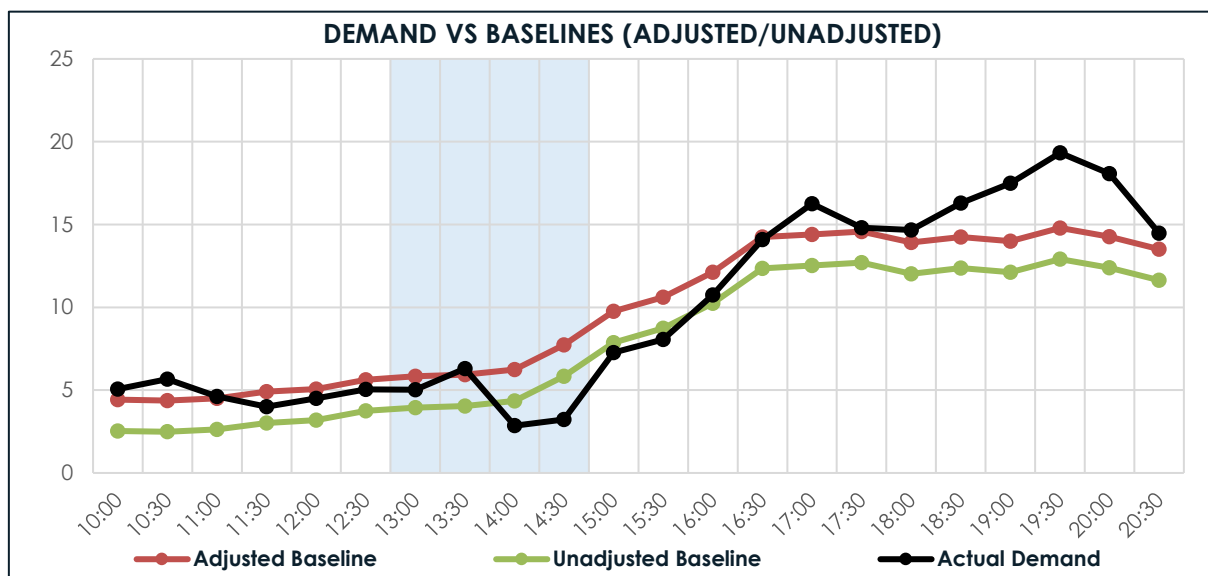of 4.2kW that is in the correct order of magnitude to help confirm the 27 February 2018 result as accurate.

Figure 2 - PI Event 8 February 2018 Results with Adjusted Baseline.

DR Delivery Conclusions for PI Group

Participation of all participants was confirmed - the linear baseline method appears consistent with the RACV results and it is supported by the more accurately representative AEMO baseline result of the 8 February 2018 event.

For these reasons, ZE considered 7.6kW to be a fair measure of the provided DR delivery for this group.

3.1.2 RACV Behavioral Programme

Event Observations

Text message alerts for the event were issued to ±1,400 programme participants. However, there was no confirmation from RACV of who participated. A non-mandatory email survey was released after the event asking for participation. However, only ±300 replied to the survey of which 117 (or 39%) indicated participation.

This list of 117 NMI's was submitted for the AEMO reconciliation rather than the full list of 1,400 as it had been shown in the 8 February 2018 event that non-participation negatively effects results.

If participation of all participants were considered, we could expect participation of roughly 50% (700 NMI's) as has been shown by the PI programme over three test events (two RERT tests and one POC test).

Some of these results, along with other participant feedback, can be found in "Zen Ecosystems DR Staff Trial Event - Nov 2017.pdf"

Event Data Analysis

Figure 3 shows the energy demand of the 117 RACV participants along with both the unadjusted, adjusted baseline and a line of best fit. ZE considers the line as best fit as the best baseline representation for ascertaining the provided demand response performance for this particular event.
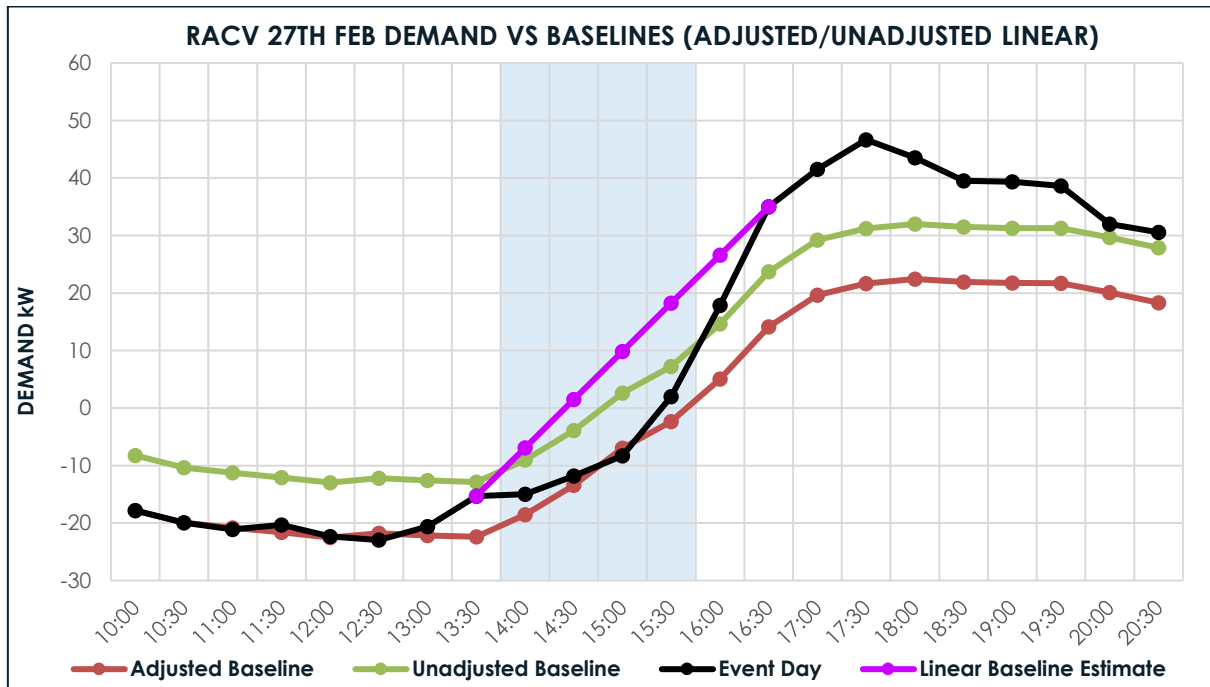

Figure 3 - Energy demand of 117 RACV participants who actively indicated event participation compared to AEMO baseline and Zen's Linear Baseline Methodology.

There are two very important observations to consider for this event:

- It was unusually cool in the morning with a low of 14°C around 6am [according to the BOM's archive data for Olympic Park weather node confirmed by and Weather Underground (online)]. In addition, it was clear and sunny which created a significant amount of solar energy in the group (see demand goes negative).
- Temperatures steadily increased through the day to 31°C by 4pm. This correlated with considerably lower than average energy usage in the morning data (which the AEMO baseline adjustment calculations utilise). Compared to the ten-day average, this meant a reduced adjusted baseline from the unadjusted. This equated to an adjusted baseline that lined up very closely in the morning, but as shown in Figure 3, was grossly incorrect in the afternoon. During the event, it was nearly entirely beneath the actual usage despite an obvious DR response visible. This resulted in a negative result of -4.09kW for the group despite an evident DR response.

Figure 4 shows the energy usage of the prior ten days including the event day. By examining, this we can devise a suitable baseline for the group.

Alternative Baseline Analysis

By observing the data from the other ten days we can see that in nearly all circumstances, a linear line of best fit would adequately equate to the data points from 13:30 to 16:30. However, for the event

day, the data is clearly non-linear with energy usage beginning to climb between 12:30 and 13:30 but dipping during the event, and then rapidly climbing during the end and after the event. This is typical to a behavioral demand response event.
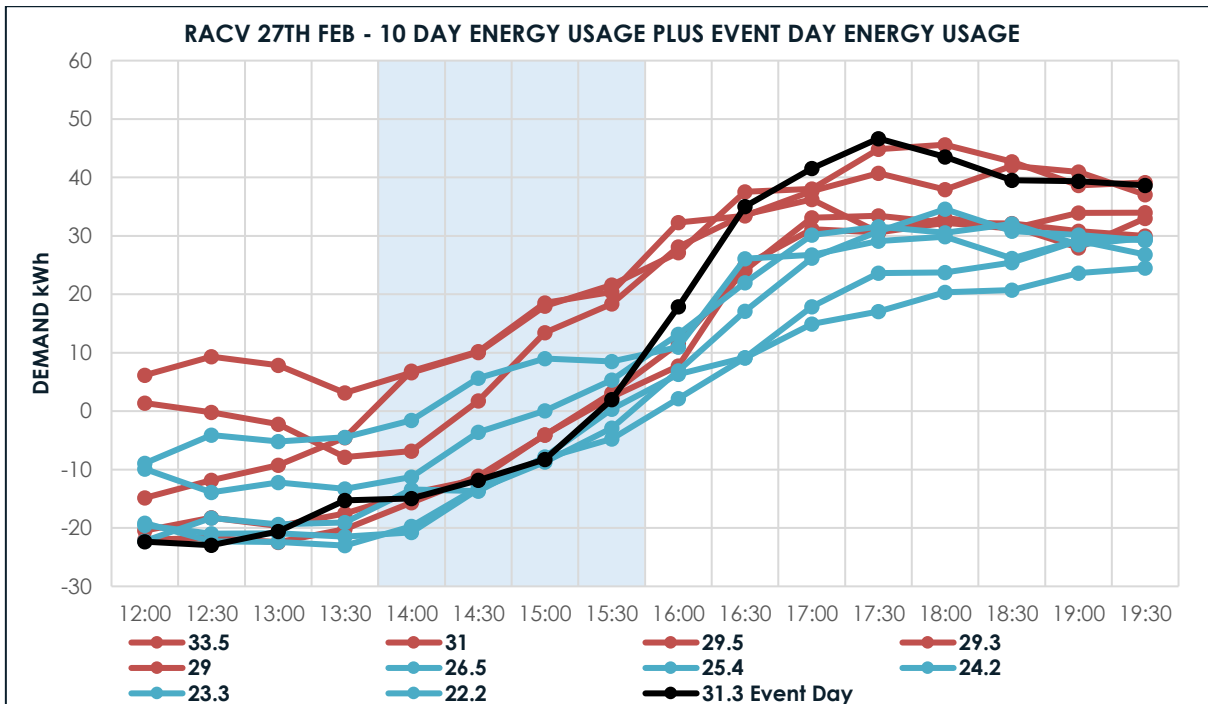

Figure 4 - 10 prior week-days of energy data plus DR event day. Days are split by colour into days with a max temperature above and below 28 degrees. Blue area is DR event time.

To create a fair baseline for this event, ZE proposed a linear line of best fit (seen in Figure 3) that emulates a typical linear rise in energy usage as shown by the previous ten days. We noticed that this line has a steeper gradient to the unadjusted baseline. This is to be expected due to the abnormal variation in temperature between morning and afternoon.

Using this baseline, the average kW delivery for the event for the RACV cohort was 27.89kW. This equates to an average reduction of 0.24kW per person during the event.

To support a delivery of 27.89kW, we can also look at the data from the 8 February 2018 event. The conditions on this day were overcast (less solar impact), warm in the morning at 20.6°C and hot in the afternoon to a moderate 27.5°C (not extreme) with a cold front blowing through right on 5pm.

As seen in Figure 5, a warm morning resulted in higher than average energy usage in the morning, corresponding to a raised adjusted baseline.
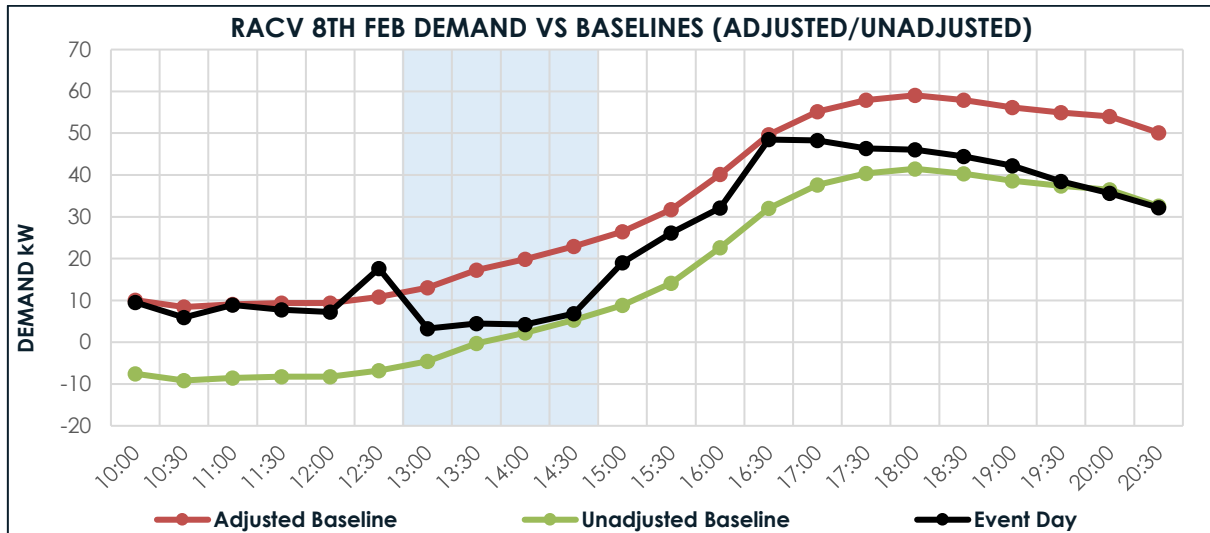
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Figure 5 - RACV YES data for DR event 8 February 2018.

On this occasion, the baseline matches well in the morning (except for a DR pre-event spike likely due to pre-cooling) as well as lining up well with the data post event at 4:30pm. However, due to the cold front, the event day data diverged abruptly from the baseline. It is not hard to imagine that if the cold front had not come through, energy usage may well have matched the baseline.

However, this test event day was not during an extreme weather event and we could expect the baseline to match well. In a real extreme weather event, we would not expect the baseline to match as well.

We could apply a line of best fit for this data as well, however, as the adjusted baseline appeared to match well already, we can use this for the DR delivery calculation that resulted in 27.14kW average delivery. This is encouraging as it is virtually identical the event for 27 February 2018, indicating the linear estimate previously described is a suitable baseline.

DR Delivery Conclusions for RACV Group

From the results depicted, ZE considers it fair for the effective DR delivered (for this group) to be counted as at least 27.89kW. If we were to extrapolate the 117 / 300 *Yes* responses (equating to 40%, plus the average observed participation rate for the PI programme of 55%) from the post event survey to the whole group of 1,400, we would expect to see a total DR delivery of approximately 130kW for the group, by including all event participants that actually participated.

We could argue that this is closer to the true DR capacity of the RACV group, however, as ZE cannot prove or confirm this number, evaluation of this will be left to the discretion of ARENA.

Total DR delivery of the PI portfolio would be 184.8kW if this was the case.

3.2   Commercial Refrigeration Performance - Frigbot

Event Observations

Frigbot was notified of the event and time, confirmed participation and scheduled the devices to trigger defrost cycles at the start time of the event. After the event, they confirmed that all Frigbot devices had reported the fridges were in defrost cycle.
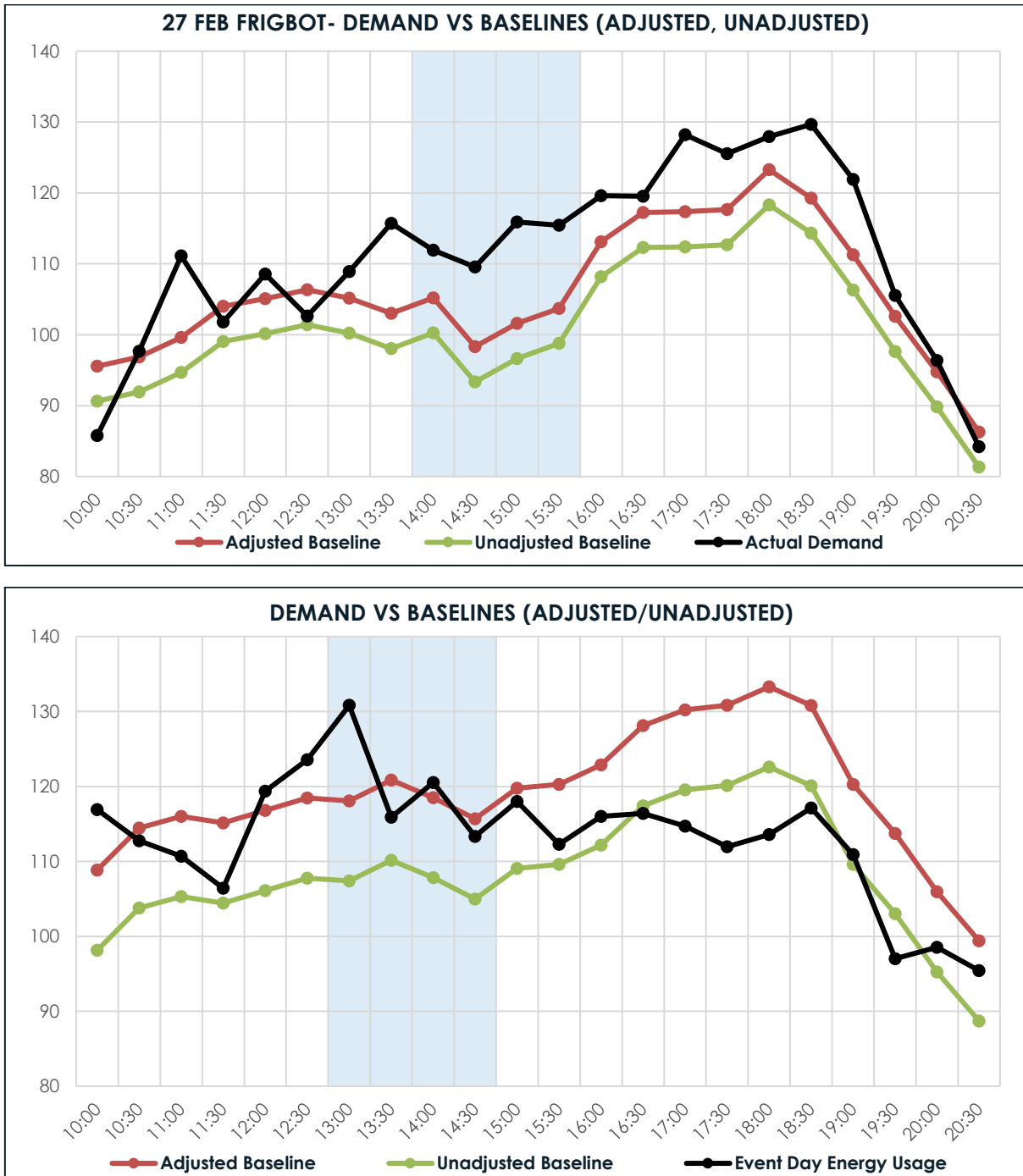
Event Data Analysis

Figure 6 - FRIGBOT data for 8 NMI's with refrigeration loads including AEMO baselines.

From the data as seen in Figure 6, no clearly distinguishable DR occurred, and in fact, for the 8 February 2018 event, there was even a noticeable spike in energy consumption for the first time-period of the event. By studying Figure 7, we can also see that the general variation in the load on the event day was entirely similar the variation seen in the other 10 days.
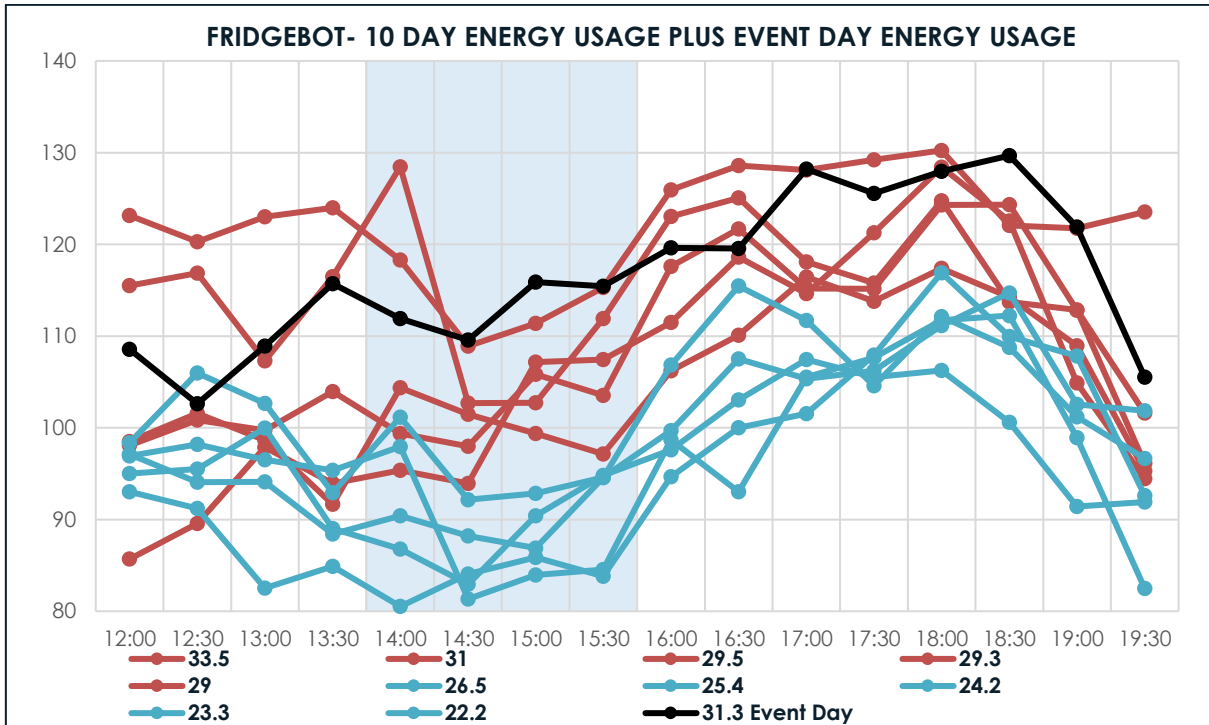

Figure 7 - 10 days of usage

DR Delivery Conclusions for PI Group

As there was no visible sign of DR in the data, for this group, ZE considered the effective DR delivery to be 0kW. More discussions about these results will be had with Frigbot to understand the unexpected results and develop improved approaches for using this type of load for DR.

3.3   Commercial Building HVAC Performance

Event Observations

For both events, the medium commercial HVAC in non-essential areas were pre-cooled for 30 minutes before the event and switched off for the full 2-hour duration of the event. The smaller commercial HVAC load's setpoint was adjusted from 23°C to 26°C via ZenHQ™ and reports from the business were that the HVAC did in fact turn off for a significant portion of the event (>1hr).

Event Data Analysis

As mentioned previously, due to privacy concerns by AEMO, cohort data was not provided for this cohort. Energy data could be calculated from the other cohorts and summary data, however, baselines could not due to the lack of baseline data in the summary data.

From the data shown in Figure, 8 there was a very distinct DR delivery during the event. A spike before was expected due to the pre-cooling and at the end to bring the building's back to the desired set-points. This kind of load represents a rather constant load profile (many HVAC loads running all day, cutting in and out produces a relatively linear load profile over a short period of two hours) and so a linear, constant baseline can be used to calculate the DR provided.

Using this method, the provided DR delivery was calculated at 47.26kW.
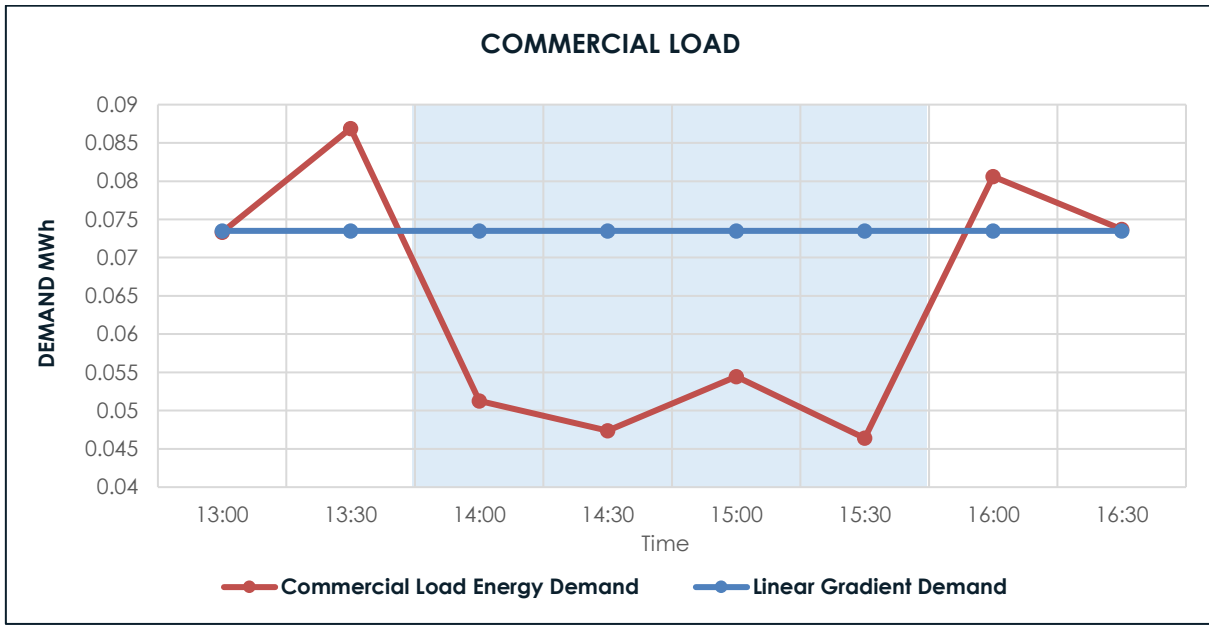
Figure 8 - Energy data on the event day Feb 28th for commercial HVAC load cohort.

DR Delivery Conclusions for PI Group

As commercial HVAC acts more like a constant load compared to residential HVAC, it can be easily characterised as one, and a simple baseline produced. This is preferable for the current AEMO baseline approach and will be the focus of future ZE endeavours to cover more HVAC load.

The current DR provided for this cohort is calculated at 47.26kW.

4. Lessons Learnt

4.1 Poor Data Access

Throughout the summer, ZE faced considerable challenges in obtaining DR participant data due to a range of issues related to data privacy concerns. As ZE is not an energy retailer, we could not economically retrieve energy data for large (e.g. >50) amounts of NMI's. This meant the performance of those NMI's that signed up for DR with ZE couldn't have their performance evaluated. This made providing incentives and reimbursement for participants very difficult. As reimbursement for cutting load is one of the fundamentals of providing the programme, this was a significant issue for running a successful programme.

It is possible to work around this issue, by providing a lottery style incentive for one programme participant to win, or providing individual incentives like movie tickets to every participant that says they participated. However, this is easily gamed.

A consolation to this problem was that for this summer, AEMO was able to provide cohorts of NMI's data without exposing any one NMI's data. This was beneficial for ZE as it allowed different types of loads e.g. commercial, behavioral, refrigeration to be grouped to assess the performance of each type of load especially highlighting baseline issues for certain load types.

However, while this was helpful, it still did not solve any of the outstanding issues with non-retailers having no access to the data of participants who have actively signed up to the DR programme and provided NMI's to ZE. It would be beneficial for a universal agreement to exist that stated that providing NMI's for DR by a customer is also agreeing to give access to their energy data.

4.2 Difficulty in Ascertaining Accurate Baseline Methodologies

As discussed in the ARENA DR workshops, the current baseline methodology was not appropriate for various types of loads that vary due to factors such as behaviour, weather or temperature. As many of ZE DR loads fell in this category, the AEMO baseline seldom produced accurate results.

As such, ZE produced a methodology for assessing DR performance primarily for it's behavioural DR loads. This used the linear profile of energy usage during that time of day to produce a line of best fit between the energy usage immediately before and after the event. It should be noted that this methodology will only be accurate during the time of day that the test events were held (1pm to 3pm and 2pm to 4pm ESDT). This is because once the energy begins to peak for the day (usually around 4pm) it becomes distinctly non-linear.

ARENA commented that for the future of the DR programme, there is a possibility to have categorisations for loads by applying different suitable baseline calculations. However, the task still remains to identify the best baseline methods for these different categorisations.

ZE attempted to produce more effective baselines:
- Using the afternoon data to adjust the mean unadjusted baseline produced more accurate baselines as these temperatures would be closer to those in the event than those in the mornings before events. However, this could create ways to game the system. It also proved to be slightly

inaccurate when ZE applied it to their groups because days that DR events are called are by their nature extreme and do not tend to follow the same shape as the average baseline days.
- The best theoretical way to produce a baseline would be to have control group for each load type; e.g. for residential behavioural DR, AEMO recruits a number of residential loads that do not participate in the DR event, however allow their data to be used for baselining.

4.3 Unexpected Behaviour of Frigbot and Refrigeration Loads

Frigbot was utilised to produce a significant load for the DR portfolio. However, from the data received, it did not appear to produce any visible DR. This was unexpected and requires further discussions with Frigbot as to the precise functioning of the devices.

Due to the large opportunity size, and the negligible impact to participants, this type of load, if understood and controlled, could prove to have significant ability for effective DR.

With some speculation, this result could be put down to a number of causes:
- The comparison to the rest of the load on these NMI's washes out the visible impact e.g. pizza ovens, HVAC, TV's etc. However, if we take a conservative estimate and expect all the device to be functioning at 25% of it's max rating (62kW as provided by Frigbot) we still would have expected at least a 15kW (~1.5kW/device) drop in power usage based on the understood size of the devices. In the scale of the graphs this should have been a noticeable drop that is clearly not evident.
- It is possible that defrost cycles in fact do not reduce power usage of a device. Some devices may require the fan to run for defrost; e.g. Fan @ 2.5kW, condenser @ 7.5kW, as the machine cuts in and out (fan and condenser) over an hour its average consumption may be ~2kW (20% @ 10kW, 80% @ 0kW). However, for a defrost cycle a fan may be constantly on for the hour so average usage is 2.5kW, higher than average for usual function.
- The Frigbot devices malfunctioned and reported turning off while failing to actually switch the device into defrost.

4.4 Testing Times and Conditions Affect Test Results

Due to a late start to the programme, as well as time required to set up a DR programme, ZE's only opportunity for providing DR was through two RERT test events. During these two events, AEMO selected the test event times to be 1pm and 2pm ESDT. In addition, these events were on warm, but not remarkably hot days as would be expected from a real DR event.

These tests were not designed to be the final record of DR ability, but as a "ball park" indication, with actual DR events serving as the final measure of a providers DR capacity.

However, for the given situations, it should be acknowledged that these events were far from an accurate portrayal of a real DR event which will typically be around 5pm ±1hr as people arrive home from work and switch on HVAC load as well as being on exceedingly hot days (not characteristic of a "baseline" or "average" day. Holding an event in the middle of the day also drastically reduces behavioural DR participants the ability to participate.

For the summer, this made up the majority of the PI DR portfolio, and as such the performance of said portfolio is expected to have suffered and so the results portrayed in this report are highly likely lower than the results that could be expected from a real event.

5.   ADDITIONAL DR ACTIVITIES

5.1   Completed Activities

ZE activities participated in for 2018 include:

- Michael Joffe, General Manager of Zen Ecosystems Australia, was a panelist at All-Energy 2018 looking at the game changers of the energy industry: How an evolving grid is bringing positive disruption to the future energy system.
- Michael Joffe, General Manager of Zen Ecosystems Australia, presented at All-Energy 2018 on Smarter Energy Use in Commercial Buildings – The Value of Intelligent Controls.
- An article was published on the Renew Economy website, April 30th 2018 regarding Zen Ecosystems backing from the federal government's Clean Energy Innovation Fund.
- An article was published in The Australian, January 31st 2018 referencing the efforts of ZE with regards to DR.
- Attendance at a number of industry related events (e.g. Australian Gaming Expo 2018; All-Energy Australia 2018).
- Pro-active customer and prospect engagement with a focus on DR.

6.   RERT PANEL AGREEMENT CONDITIONS PRECEDENT

ZE considers the five conditions of the Conditions Precedent fulfilled.

CONDITION	FULFILMENT
1	**Completed.** Refer "Zen RERT Industry Trial Participant Record 24 Oct 2017.docx" of data pack.
2	**Completed.** Refer "Zen RERT Industry Trial Participant Record 24 Oct 2017.docx" of data pack. Also see "Zen Ecosystems DR Staff Trial Event - Nov 2017.pdf" for confirmation of load providers successful ability to activate load within given timeframe.
3	**N/A.** No "standby generation" being provided.
4	**Completed.** NMI's provided to AEMO for two test events on 8 and 27 February 2018.
5	Due to the broad range of reserve types, each requiring different contractual arrangements, there was no "standard" contact provided to AEMO.