ZEN ECOSYSTEMS™

Planet Innovation RERT Demand Response Program Performance Summary (Summer 2017/18)

17 May 2018

REVISION HISTORY

Version	Date	Modified By	Comments
1	May 4th 2018	Bede Wolfenden	First Release
2	-	-	-

This Activity received funding from ARENA as part of ARENA's Advancing Renewables Programme - Demand Response.

1. Program Summary

This report documents the performance, learnings and findings of the Planet Innovation (PI) demand response program, run by Zen Ecosystems. The activities covered include knowledge sharing activities, test RERT events and documented difficulties that were encountered through the programs creation and execution. This includes:

- NMI & Data Stream Suffix Collection Issues (Nov 27th)
- PI DR Staff Trial (Nov)
- PI DR Learnings for Scale (for a large third-party DR program) (Dec 13th)
- Test RERT Event (Feb 8th)
- Test Event Summary Report (Feb 13th)
- Test RERT Event (Feb 27th)
- ARENA DR Workshop (Mar 8th)

The documents/data included in the data pack for (and including) this report are:

- Data Stream Suffix Collection Issues Report.pdf
- Zen Ecosystems DR Staff Trial Event - Nov 2017.pdf
- PI DR Learnings for Scale.pdf
- Zen Ecosystems DR Event Summary - Feb 8 2018.pdf
- PIDR_TEST_DATA_ANALYSIS.xlsx
- Raw AEMO Report Data
    - 20180208_TEST_MJ005_summary.xlsx
    - 20180227_TEST_MJ005_Summary.xlsx

1.1 Program Performance Summary Table

DR Load Type	AEMO Adjusted Baseline Performance (kW)	Zen Ecosystem's Alternative Baseline Performance (kW)
RACV Behavioral Program	-4.09	27.9
PI Behavioral Program	-2.93	7.59
FRIGBOT	-21.98	0
Commercial Buildings	43.60	47.257
TOTAL	**14.60**	**82.72**

2. Overview of DR Being Provided

Zen Ecosystems goal for providing Demand Response (DR) is 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.

The PI DR load portfolio for 2017/18 Summer involves a broad span of demand response loads located in Victoria and that fall into 3 main categories:

- Behavioral Demand Response (~1450 NMI's)
- Commercial refrigeration NMI's (20) with remote/wireless control
- Commercial building NMI's (5) with manual and Zen controlled HVAC loads.

2.1 Behavioral DR Programs

2.1.1 PI Behavioural DR program

The PI "Save the Grid" demand response program was the forerunner to the larger RACV "Help the Grid" program (see below) and provided the learnings and frame work used for the RACV program. It contains a total of 50 NMI/s that covered a variety of Zen controlled residential HVAC loads as well as behavioural load, controlled by PI staff, family and friends. The incentive for participation was 2x movie tickets for Hoyts cinemas per event participated in.

2.1.2 RACV "Help the Grid" DR Program

RACV partnered with Zen Ecosystems as a contributor to PI's DR load portfolio. The load was provided in the form of behavioural demand response of members who had enrolled in the RACV "Help the Grid" program. This program was launched on Jan 30th and at the time of the first event on Feb 8th had ~1300 NMIs/members enrolled in the program. This enrollment increased to ~1400 NMIs by the second test event on Feb 27th. To incentivise enrollment and participation, members were offered the chance of winning an all-inclusive weekend away for two at RACV's prestigious Torquay resort.

2.2 Commercial Refrigeration Load – FRIGBOT

Frigbot specialises in retrofitted remote control of refrigeration load. This technology allows remote wireless control of large refrigeration devices such as cool rooms, refrigeration cabinets and chest freezers. The opportunity size for this is huge with 100,000's of such devices spread through hospitality establishments everywhere. FRIGBOT's device provides DR by triggering refrigeration devices defrost cycles remotely which is not noticeable by the customers and is part of the devices normal daily operation. The current number of devices under control by FRIGBOT is approximately 30 large refrigeration devices (on a total 20 establishments/NMI's) such as cool rooms of pub's and restaurants around Mornington peninsula. However, NMI's for only 8 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, ~2400m^2, 20x 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 , < 5x control points, provided HVAC load controlled remotely via ZenHQ. During an event the set-points of the AC systems were increased by 3°C by Zen Ecosystems via ZenHQ.

3. Performance Analysis

Over the course of the summer, 2 RERT test events were requested and executed by Zen Ecosystems on the 8th Feb and 27th Feb 2018.

8th Feb

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, Zen Ecosystems 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 which 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 1400 RACV program participants whether they participated in the event or not. This was suspected as the primary cause of the poor result and so later requested 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 event 27th Feb will be used as the benchmark for the PI DR performance with results from the 8th providing support.

27th Feb

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 minus 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 however that as 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 characterize varying loads such as behavioral and temperature dependent HVAC Zen Ecosystems will propose an alternative baseline for some of the cohorts namely the 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 (28th Feb) as determined by Zen Ecosystems is **82.72kW.**

3.1 Behavioral DR Program Performance

3.1.1 PI Behavioral DR Program

Event Observations

Event execution appeared to be 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 then sent out to confirmed participants after the event.

Event Data Analysis

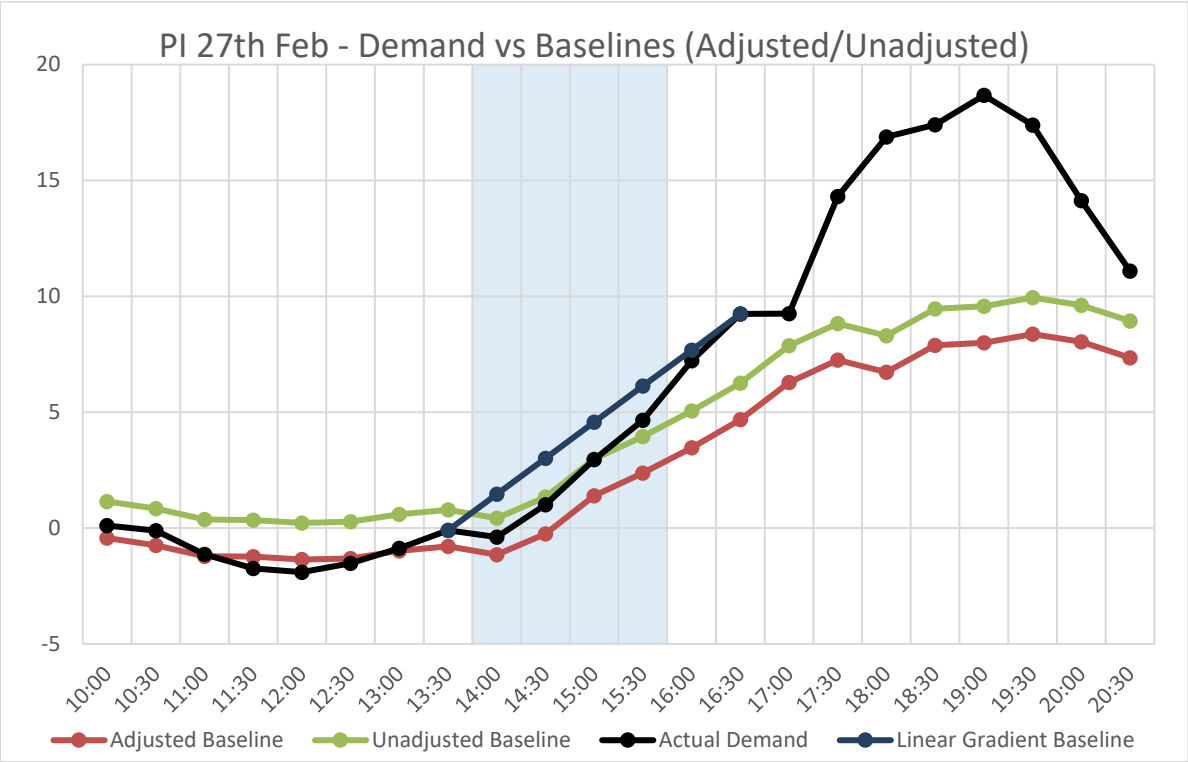


Figure 1 - Energy demand of 27 YES participants who actively indicated event participation compared to AEMO baselines and Zen's Linear Baseline methodology

As will be 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) which created a negative result of -2.93kW despite a visible DR response.

Alternative Baseline Analysis

As shown in Figure 1, energy begins to rise from 12:00 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, we observe a DR delivery of **7.6kW** (0.28kW/person) which is close in size to the RACV results on a per person level.

Looking at the event 8th Feb and using the adjusted baseline (which lines up suitably for this day) like in the RACV group we see in Figure 2 a noticeable dip during the event time and a DR delivery of **4.2kW** which is in the correct order of magnitude to help confirm the Feb 27th result as accurate.

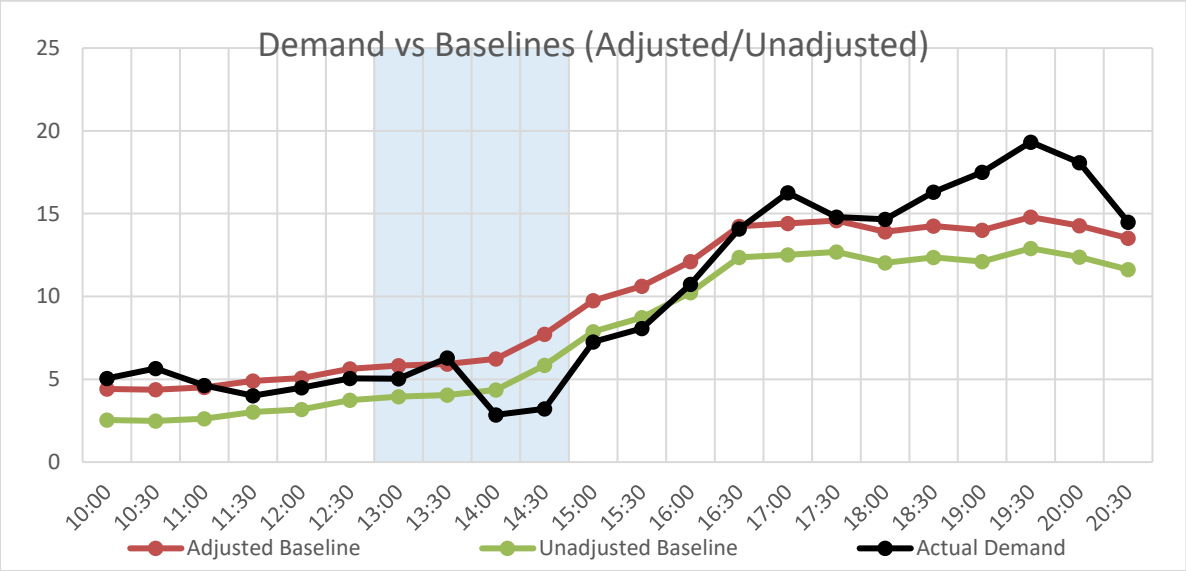


Figure 2 - PI Event 8th Feb Results with adjusted baseline

DR Delivery Conclusions for PI Group

Participation of all program 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 8th. For these reasons Zen Ecosystems considers **7.6kW** to be a fair measure of the provided DR delivery for this group.

3.1.2 RACV Behavioral Program

Event Observations

Text message alerts for the event went out to the entire 1400 program participants. However, there was no hard confirmation of who participated that was collected by RACV. A non-mandatory email delivered survey was sent out some period 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 1400 as it had been shown in the Feb 8th event that non-participation negatively effects results. If participation of all program participants was taken we could expect participation of roughly 50% (700 NMI's) as has been shown by the PI program over 3 test events (2 RERT Test, 1 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 which Zen ecosystems considers the best baseline representation for ascertaining the provided demand response performance for this particular event.

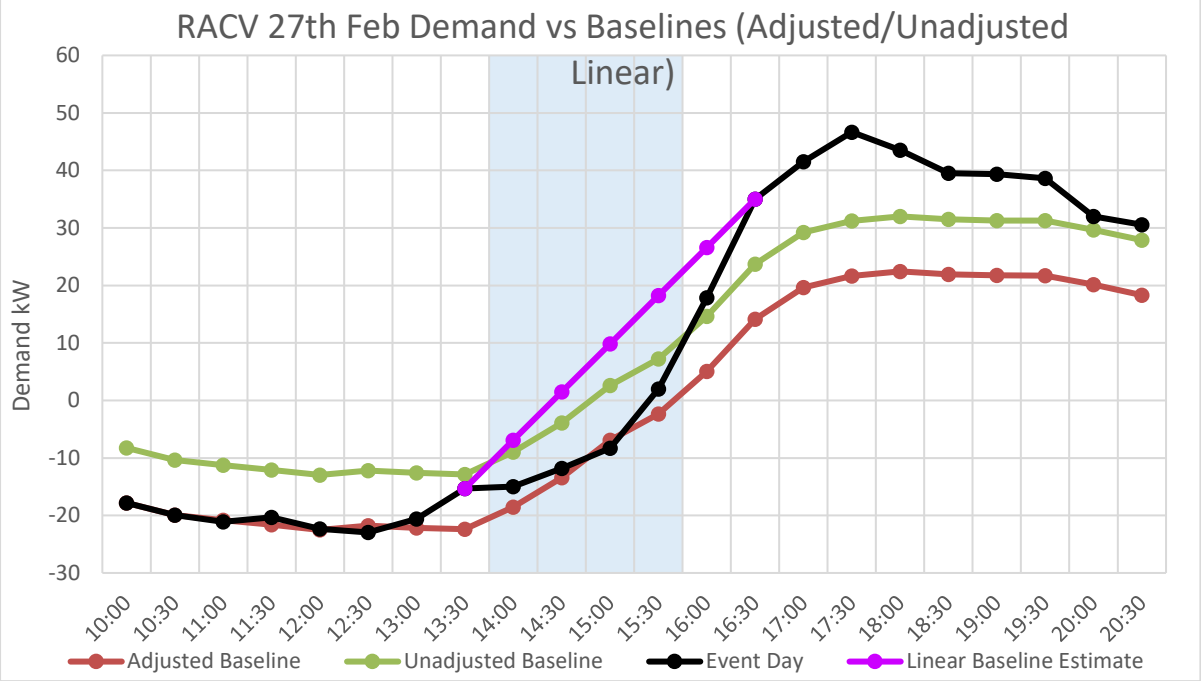


Figure 3 - Energy demand of 117 RACV participants who actively indicated event participation compared to AEMO baseline and Zen's Linear Baseline methodology

There are two very important observations to consider for this event. The first is that 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 then rose steadily through the day to 31°C by 4pm and for the next few hours. This correlated with considerably lower than average energy usage in the morning data (which the AEMO baseline adjustment calculations utilize). Compared to the 10-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 and during the event is 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 10 days (also see PIDR_ALL_TEST_DATA_ANALYSIS.xlsx in supporting data pack) 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.

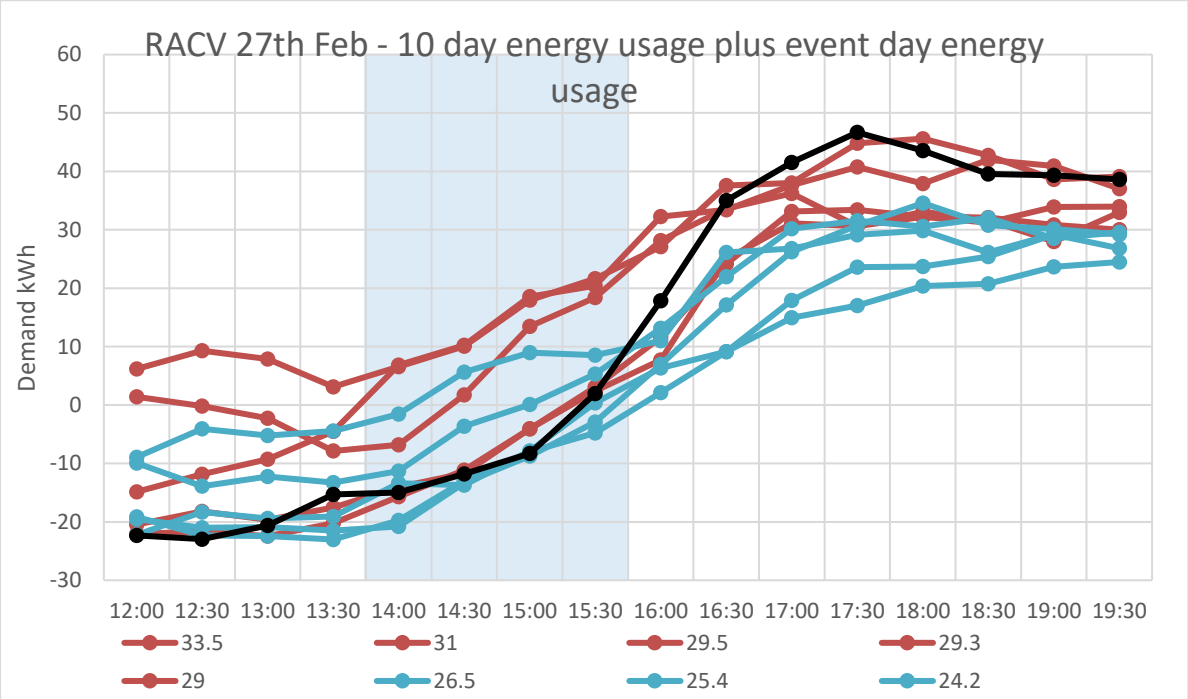


Figure 4 - 10 prior week-days of energy data plus DR event day. Days are split by colour into days with a max temperature above and below 28 degrees. Blue area is DR event time.

To create a fair baseline for this event Zen Ecosystems proposes a linear line of best fit (seen in Figure 3) that emulates a typical linear rise in energy usage as shown by the previous 10 days. We notice 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. Supporting calculations for these figures can be found in supporting data pack provided with this report in the excel document "PIDR_ALL_TEST_DATA_ANALYSIS.xlsx" under the "RACV_YES_27" tab.

To support a delivery of 27.89kW we can also look at the data from 8th Feb event. The conditions this day were overcast (less solar impact), warm in the morning at 20.6°C and hot in the afternoon to a moderate degree 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.

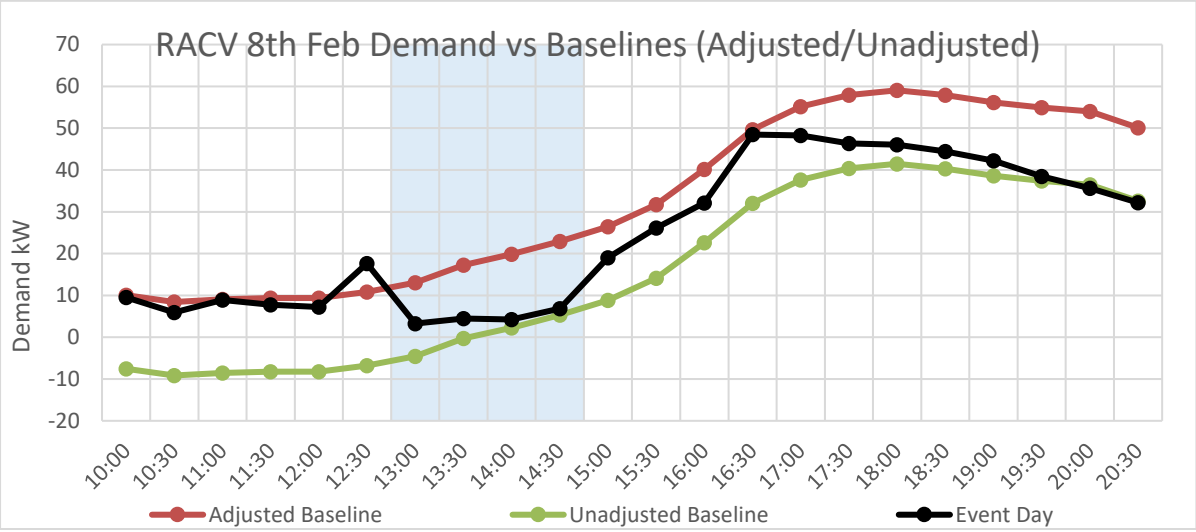


Figure 5 - RACV YES data for DR event 8th Feb

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 then diverges 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 well. However this test event day was not an extreme weather event and so 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 also, however as the adjusted baseline appears to match well already so we can use this for the DR delivery calculation which results in 27.14kW average delivery. This is very encouraging as it is nearly identical the event for Feb 27th indicating the linear estimate previously described is a suitable baseline.

DR Delivery Conclusions for RACV Group

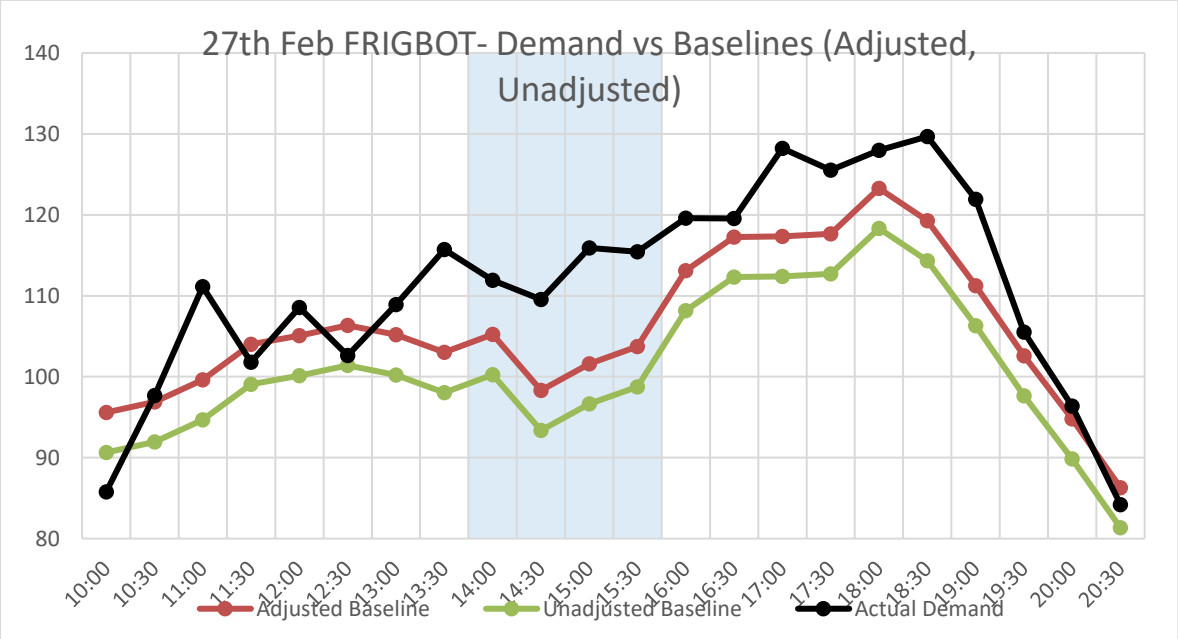
From the results depicted here Zen Ecosystems would consider it fair for the effective DR delivered for this group to be counted as at least **27.89kW**. If we were to extrapolate the 117/300 YES responses (equates to 40%, plus the average observed participation rate for the PI program was 55%) from the post event survey to the whole group of 1400 we would expect to see a total DR delivery of roughly **130kW** for the group by including all event participants that actually participated. One could argue that this is closer to the true DR capacity of the RACV group, however, as Zen Ecosystems 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, they 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 putting the fridges into the defrost cycle.

Event Data Analysis



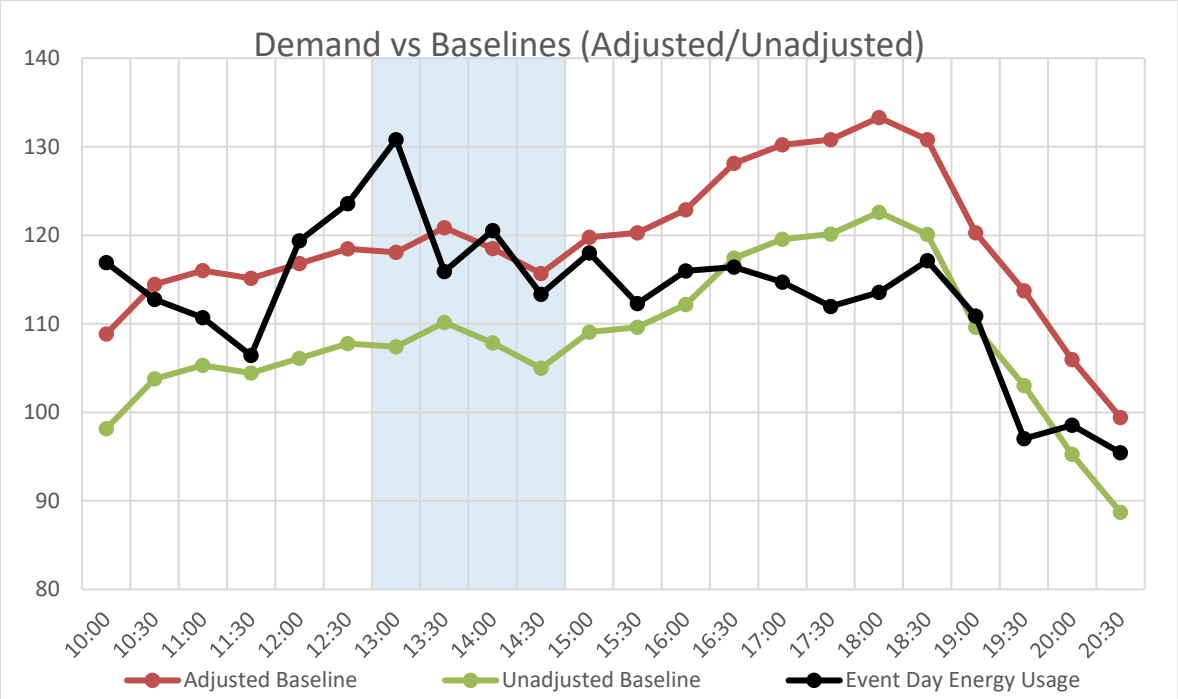


Figure 1 - FRIGBOT data for 8 NMI's with refrigeration loads including AEMO baseline's

From the data as seen in Figure 6 there is no clearly distinguishable DR occurring and in fact for the 8th Feb event there was even a noticeable spike in energy consumption for the first

time-period of the event. By looking at Figure 7 we can also see that the general variation in the load on the event day is entirely similar the variation seen in the other 10 days.

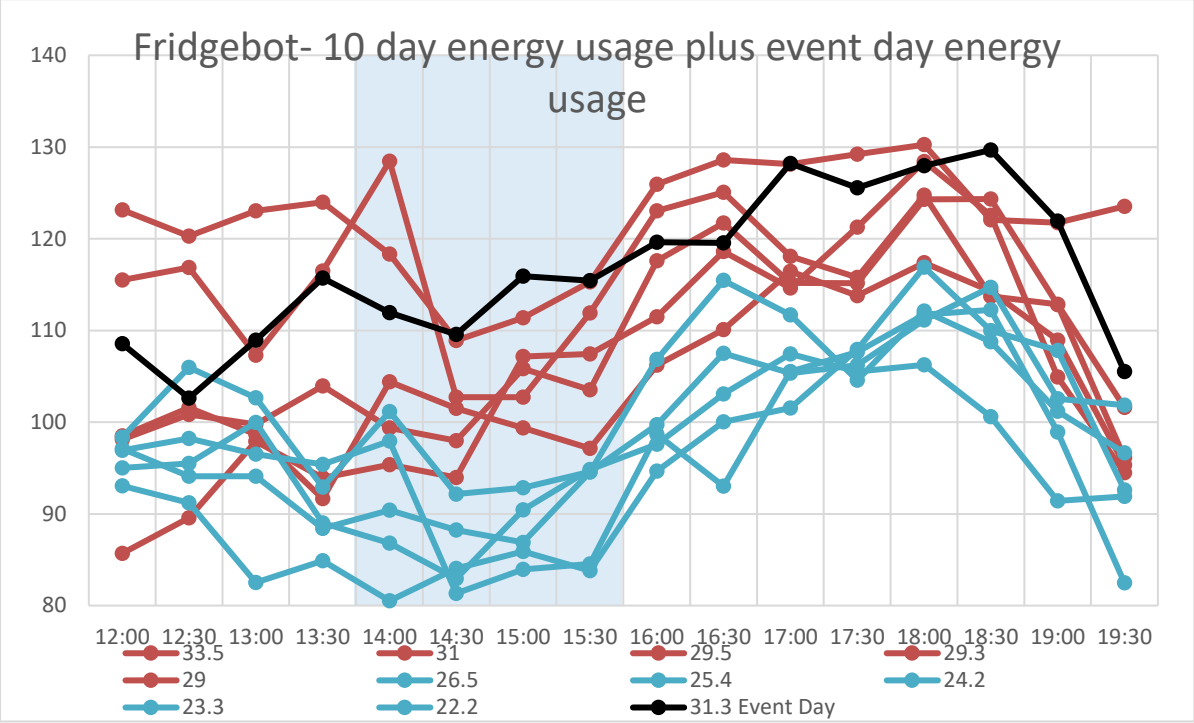


Figure 2 - 10 days of usage

DR Delivery Conclusions for PI Group

As there is no visible sign of DR in the Data, for this group Zen Ecosystems considers the effective DR delivery to be **0kW**. More discussions with FRIGBOT about this result will be made to understand the unexpected result and also 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 then switched off for the full duration 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 are 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 is a very distinct DR delivery during the event. A spike before is 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 2 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.**

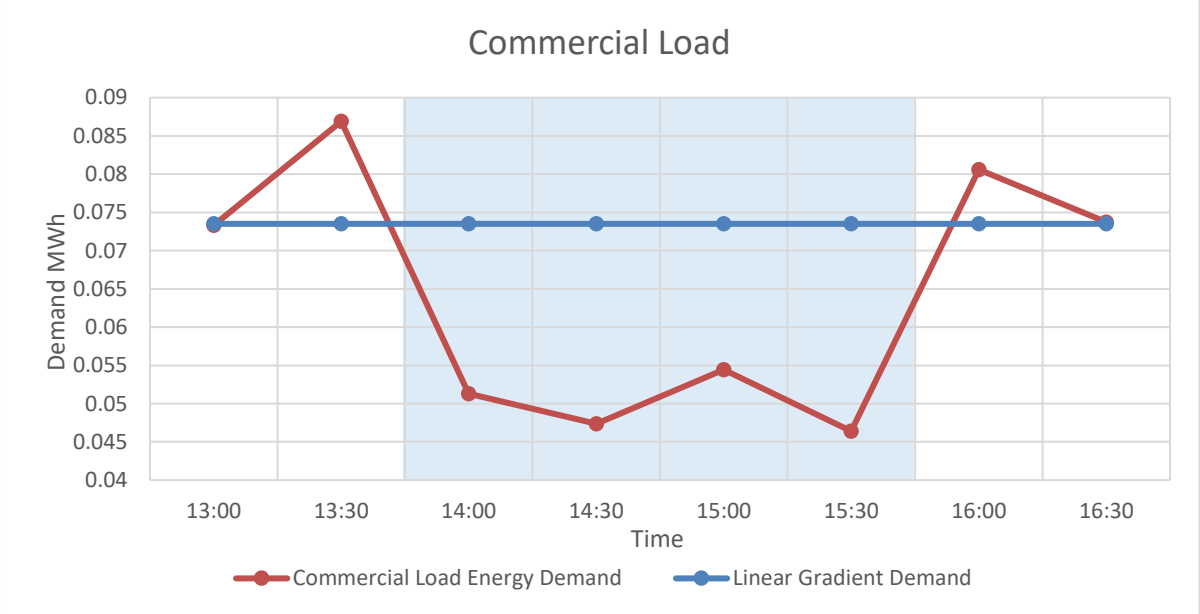


Figure 3 - Energy data on the event day Feb 28th for commercial HVAC load cohort.

DR Delivery Conclusions for PI Group

As commercial HVAC acts more like a constant load as compared to residential HVAC is can be more easily characterized as one and a simple baseline produced. This is preferable for the current AEMO baseline approach and will be the focus of future Zen Ecosystems endeavor to cover more HVAC load. Currently the DR provided for this cohort is calculated at **47.26kW.**

4. Lessons Learnt

4.1 Poor data access for non-retailers causes significant difficulties

Throughout the summer Zen Ecosystems has faced considerable trouble with regards to obtaining DR participant data due to privacy of data. As Zen Ecosystems is not an energy retailer we could not economically retrieve energy data for large (e.g. >50) amounts of NMI's. This means the performance of those NMI's that have signed up for DR with Zen Ecosystems cannot have their performance evaluated. This makes providing incentives and reimbursement for participants very difficult and as reimbursement for cutting load is one of the fundamentals of providing the program, this is a significant issue for running a successful program.

It is possible to work around this issue, like providing a lottery style incentive for one program 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 as to not expose any one NMI's data. This was beneficial for Zen Ecosystems 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 is helpful it still does 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 program and provided NMI's to Zen Ecosystems. It would be highly beneficial for some 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 Accurate baseline methodologies are difficult to ascertain

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

As such, Zen Ecosystems 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 has commented that for the future of the DR program the possibility to have categorisations for loads for applying different suitable baseline calculations, however the task still remains to identify the best baseline methods for these different categorisations. Zen Ecosystems had some attempts to produce more effective baselines:

- Using the afternoon data to adjust the mean unadjusted baseline will produce more accurate baselines as these temperatures will be closer to those in the event than those in the mornings before events. However, this could create ways to game the system and also proved to be not entirely accurate when Zen Ecosystems 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 FRIGBOT and refrigeration loads did not act as expected

FRIGBOT was hoped to produce a significant load for the DR portfolio however from the data 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. However 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's 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 it's 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 FRIGEBOT devices malfunctioned and reported turning off while failing to actually switch the device into defrost.

4.4 Testing times and conditions significantly effect test results

Due to a late start to the program and time required to set up a DR program Zen Ecosystems only opportunity for providing DR was through two RERT Test events. During these two events AEMO chose 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. It is likely that these tests are 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 situation Zen has found itself in whereby these tests events are the benchmark for performance it should be acknowledged that these events are 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 this 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

No other commercial or wholesale DR activities (pertaining to the DR funded under this agreement) were participated in.

6. RERT Panel Agreement Conditions Precedent

As per the "Annexure to Schedule 1 – Conditions Precedent" of the "RERT_Panel_Agreement.pdf" contract (contained in data pack), Zen Ecosystems considers the 5 conditions of the Conditions Precedent fulfilled.

Condition	Fulfillment
1	Complete - see "Zen RERT Industry Trial Participant Record 24 Oct 2017.docx" of datapack
2	Complete - see "Zen RERT Industry Trial Participant Record 24 Oct 2017.docx" of datapack. 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	Complete - NMI's provided to AEMO for 2x test events 8th Feb and 27th Feb 2018
5	Due to the broad range of reserve types each requiring different contractual arrangements there was no "standard" contact provided to AEMO.