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CSIRO Synergy Building Preliminary M&V Report

Measurement and Verification of

Exergenics Chilled Water Plant Optimisation

4th March 2022

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Executive Summary

This report outlines the Measurement and Verification (M&V) of the Energy Conservation Measures (ECMs) that were recommended by Exergenics and commissioned by Control & Electric. CSIRO engaged Exergenics to model and optimise the Synergy Building (Building 801, Black Mountain Canberra) chilled water plant using data collected from the Data Clearing House (DCH). Modelling was carried out by Exergenics in October 2021 and the updated control strategy was commissioned by Control & Electric on January 25th, 2022. M&V was conducted by Exergenics to quantify the energy consumption (kWh) and peak demand (kVA) savings resulting from the updated controls.

The M&V methodology chosen was Option B (Retrofit Isolation) of the International Performance Measurement and Verification Protocol (IPMVP).

Key findings from the M&V are listed below:

- Energy savings: 2,049 kWh
- Carbon abatement: 1.6tCO_2e (assumes ACT grid emissions intensity of 0.79kg CO_2e/kWh)
- Cost savings: $307 (assumes blended electricity tariff of 15c/kWh)

Due to the limited amount of time elapsed since the implementation of the ECMS this report was only able to cover a 32 day period of which there was a high cooling demand for the building. Whilst the benefits of the ECM are expected to continue, the energy avoided is not expected to remain as proportionately high during lower cooling demand periods. Preliminary projections by Exergenics have shown a 1.7% reduction in energy consumption. This report will be revisited at a later date to confirm the long term benefit of the ECMs.

Project Context

Exergenics was engaged by CSIRO to provide chilled water plant optimisation recommendations (the ECMs) at the Synergy Building, Black Mountain facility in Canberra. The building is primarily used for laboratory and office work. This report was requested by CSIRO to measure and verify the energy and peak demand savings resulting from the optimisation recommendations.

The ECM consisted of several control optimisation strategies and were applied to the chillers and cooling towers via the BMS on January 25th 2022.

Key chilled water plant control strategy recommendations of this report:

- Chiller staging setpoints

Project Boundary

This M&V report is focussed on the chiller plant and dry coolers at the Synergy Building, Black Mountain, Canberra. The equipment is located on the rooftop plant room of the building. The primary chilled water system is comprised of three air cooled York screw chillers with associated primary chilled water circulating pumps and system controls.

IPMVP Option Chosen – Option B

The Option B of the IPMVP was used: retrofit isolation, measurement of all the parameters, according to the IPMVP Core Concepts 2016. The boundary is defined by the electricity meter serving the chilled water plant room and independent variables covering the chilled water produced and Cooling Degree Days (CDD) (with a 12°C reference temperature).

The option is justified because the consumption of the electrical meter covers all the plant associated with the production of chilled water and the rejection of heat in the building.

Baseline and Reporting Period details

	Start Date	End Date	Days Total
Baseline Period	23/6/20	24/1/22	580
Reporting Period	26/1/22	27/2/22	32

Modelling Variables Summary

Independent Variables

The building load (kWrh) was calculated using the instantaneous flow, differential in entering and leaving temperatures of each chiller and the specific heat of water (4.18 kJ/kg°C) aggregated into a daily consumption value.

CDD was calculated using the average of the maximum and minimum temperatures aggregated daily using a reference temperature of 12°C.

Type	Source	Aggregation
Building Cooling Load (kWrh)	DCH	Daily
CDD (12°C Reference)	DCH	Daily

Dependent Variables

The chilled water system energy was the sum of the following variables, aggregated daily:

- Chiller energy consumption. This variable was sourced directly from the site electricity meter, B801_MCC0404. This meter covers the three chillers.
- Chilled Water Pump energy consumption. The three chilled water pumps are constant speed and a fixed energy consumption was assigned to each pump whilst it was running of 7.5 kW.

Type	Source	Aggregation
Chilled Water System Energy (kWh)	Sum of Chiller Energy and Chilled Water Pump Energy	Daily
Chiller Energy (kWh)	DCH: B801_MCC0404	Daily
Chilled Water Pump Energy	Engineering calculation	Daily

Static Factors

The static factors were as follows:

- Chilled and pumping water equipment (Chillers and associated pumps) are static or replaced like for like.
- Building floor size
- Building fabric
- Chilled Water leaving temperature setpoint

Changes to static factors

None were identified.

Baseline Adjustments

None were required.

Baseline Energy Model

We performed regression on the chilled water plant electrical energy consumption by using the Cooling Degree Days (CDD) with a 12°C reference temperature and daily cooling demand in kilowatt refrigeration hours (kWrh). The regression yielded a strong correlation across the baseline period.

A multivariate least-squares bi-linear regression function the following model was produced:

Linear model:

f(x,y) = p00 + p10*x + p01*y

where,

f(x,y) = Predicted Daily Mechanical Equipment Energy Consumption (kWh)

x = Daily Cooling Degree Days with a 12°C reference temperature (CDD_12)

y = Daily Building Cooling Load (kWrh)

Coefficients:

p00 = 87.26

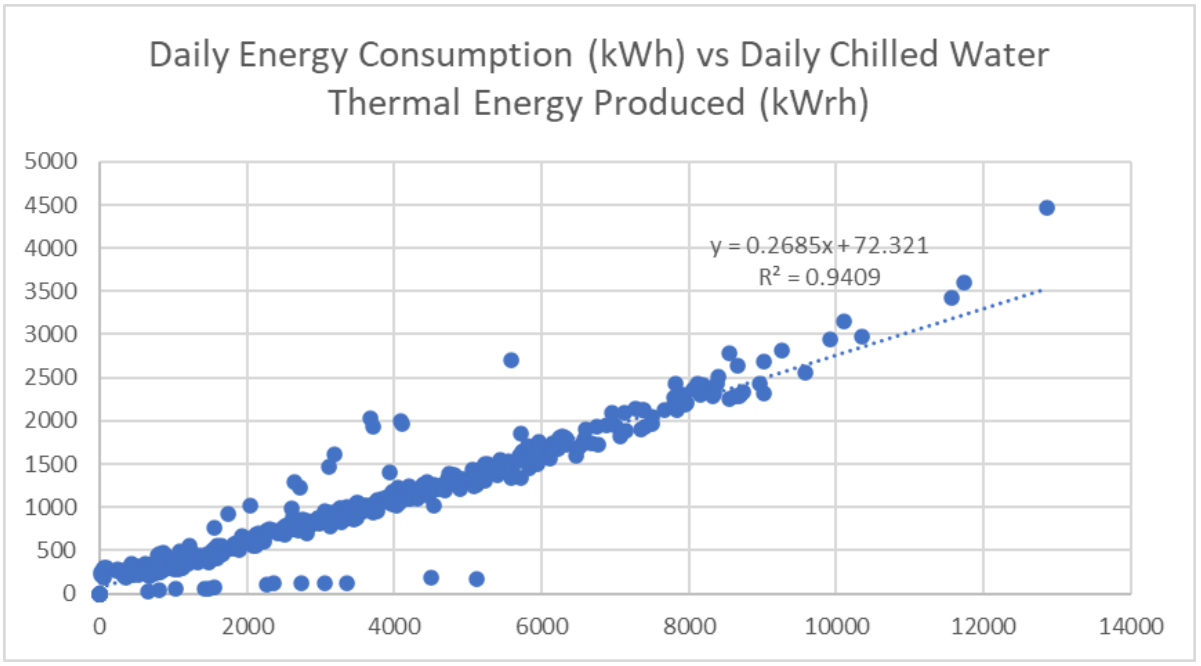
p10 = 26.90

p01 = 0.227

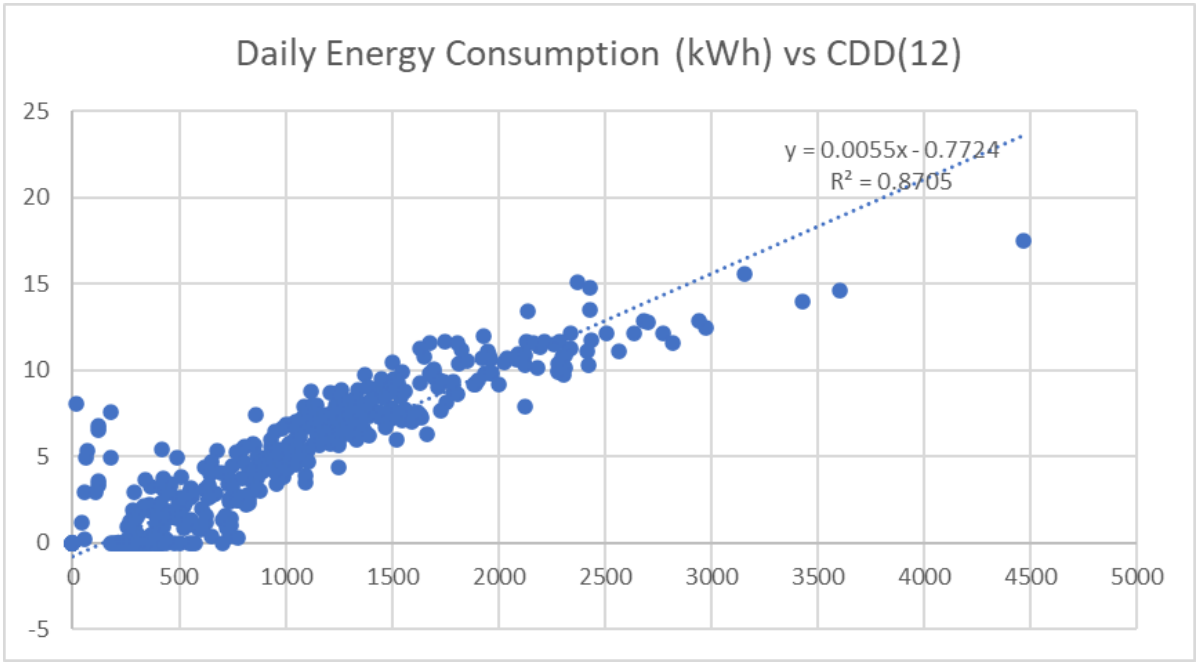
Goodness of fit:

R-square: 0.94

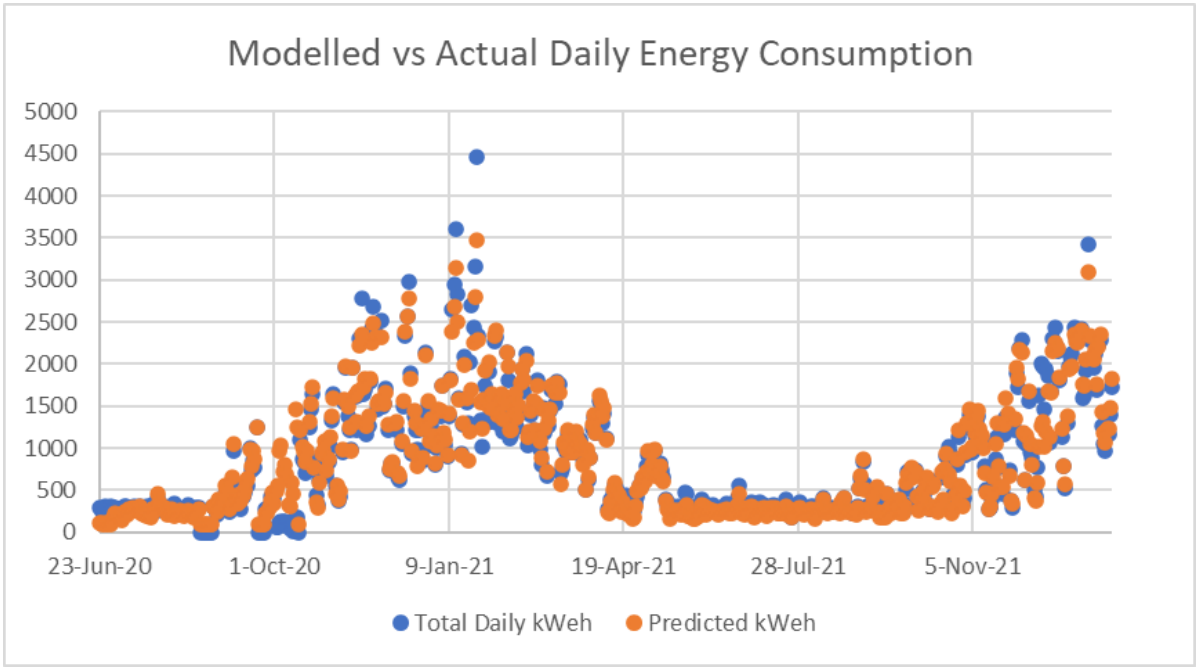
The figure below shows the relationship between daily energy consumption and the independent variable, daily chilled water thermal energy production.



The figure below shows the relationship between daily energy consumption and the independent variable, CDD.



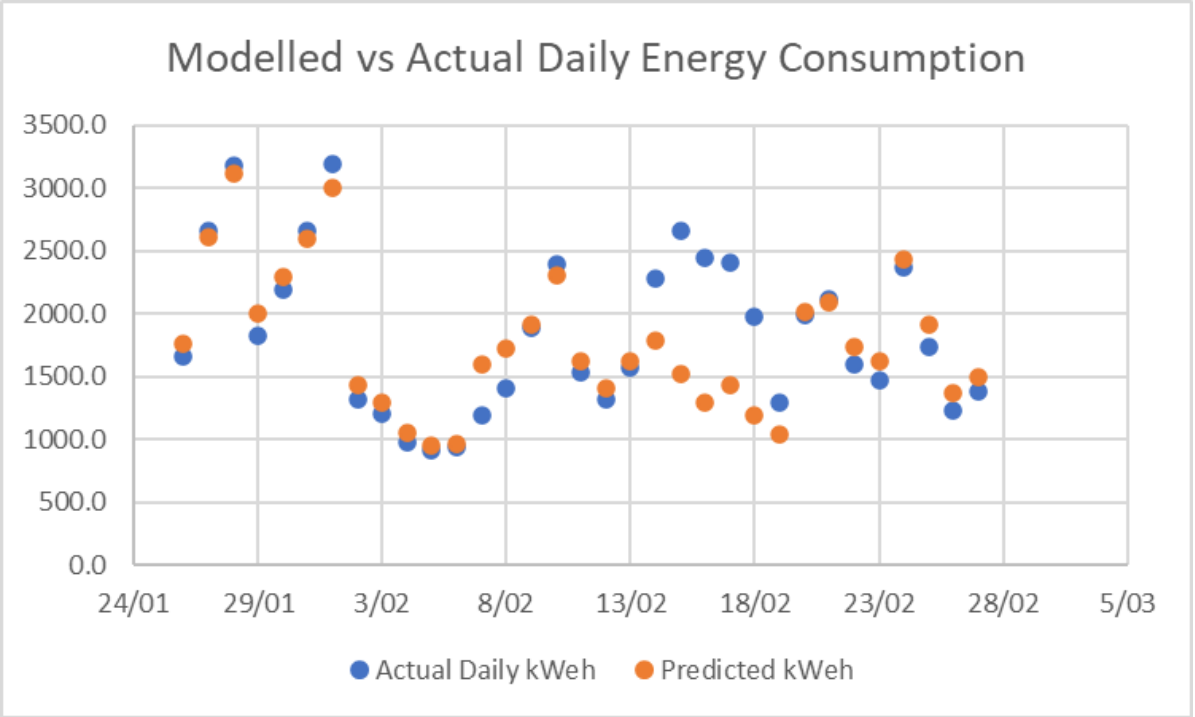
The figure below shows the relationship between actual energy consumption and the regression model built from CDD and daily chilled water thermal energy production.



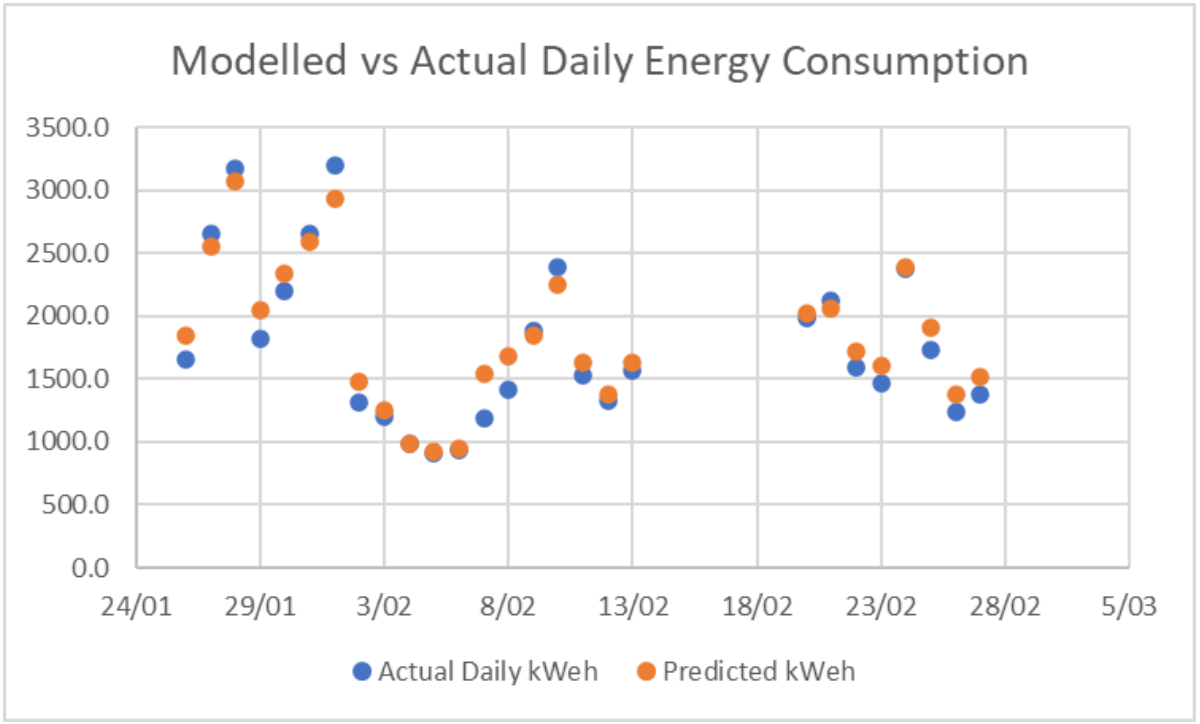
Reporting Period

Outliers in the Reporting Period

The figure below shows the actual consumption versus the predicted (modelled) consumption. Generally there is a strong relationship between the modelled and the actual consumption - with a modest reduction in actual energy consumption overall. However there is a significant outlier period (14th -19th February 2022) which would skew the results. Exergenics has reviewed the source of these outliers and determined that those days should be excluded from the reporting period. A comprehensive analysis has been included in this report.

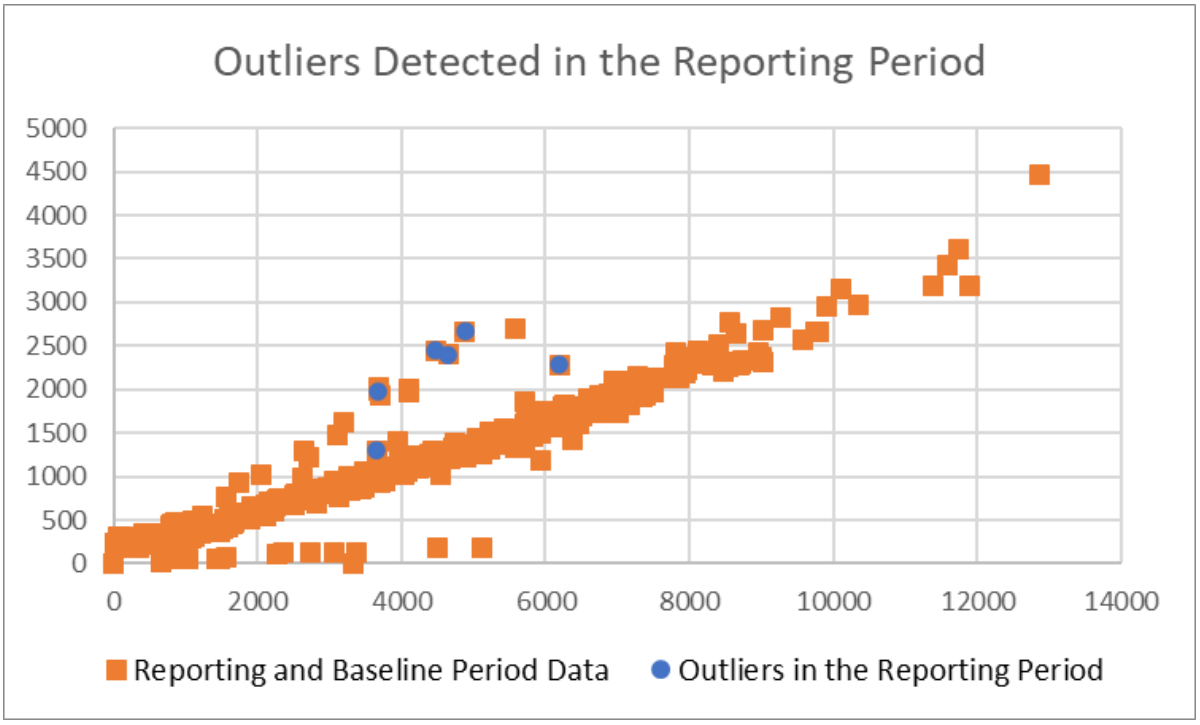


The figure below shows the same modelling, but with the exclusion of the outlier data.

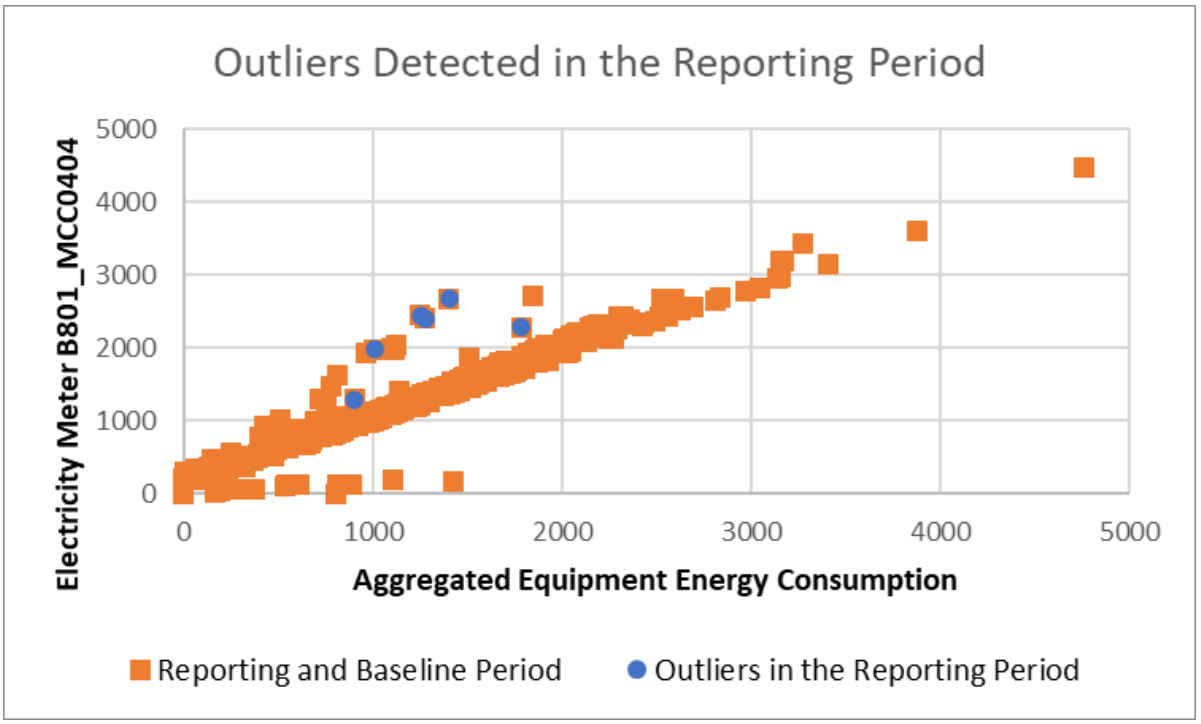


Outlier Investigation

The figure below shows 6 data points in the reporting period that were identified as unusual. Given the relatively small data set (32 points) in the reporting period versus 580 in the baseline these anomalies provided significant error in the final savings result and have been removed from the overall calculations.



Further analysis of the electrical metering data determined that there was an error with the data reported by the electrical meter. The figure below shows an alternative calculation of the chilled water plant energy consumption (calculated using the individual BMS points for the chillers and pumps, from the power consumption (kW) point on the high level interface for each equipment - these are compared against the energy consumption as reported by the electrical meter B801_MCC0404. There is a very strong linear relationship between the two sources, noting there were only a handful of outlier points in the dataset.



Final Results

Using the regression model developed above it is possible to predict the energy consumption of the chilled water plant after the ECMs were implemented on January 25th 2021. This was used to calculate the avoided energy consumption in accordance with IPMVP principles. The model was used to produce the table below which summarises the predicted versus actual energy consumption during the reporting period. There is a total reduction in actual energy consumption during the reporting period of 4.3%, clearly demonstrating the success of the ECM.

Totals	Values
Actual Energy Consumption (kWh)	47,934
Adjusted Baseline Energy Consumption (kWh)	49,984
Energy Avoided (kWh)	2,049
Energy Avoided (%)	4.3 %

Reporting Period Data

Date	CDD	Cooling Demand (kWrh)	Actual Energy Consumption (kWh)	Adjusted Baseline Energy Consumption (kWh)	Energy Avoided (Loss) (kWh)
26-Jan-22	8.9	6307	1661	1760	99
27-Jan-22	11.1	9787	2661	2611	(50)
28-Jan-22	12.4	11883	3179	3123	(56)
29-Jan-22	10.5	7175	1823	2002	179
30-Jan-22	10.4	8466	2198	2291	93
31-Jan-22	10.7	9756	2658	2594	(64)
1-Feb-22	12.2	11377	3194	3001	(193)
2-Feb-22	6.2	5191	1321	1433	112
3-Feb-22	5.9	4605	1204	1294	90
4-Feb-22	5.4	3609	981	1053	72
5-Feb-22	5.7	3119	913	948	35

Date	CDD	Cooling Demand (kWrh)	Actual Energy Consumption (kWh)	Adjusted Baseline Energy Consumption (kWh)	Energy Avoided (Loss) (kWh)
6-Feb-22	4.9	3279	938	965	27
7-Feb-22	5.9	5924	1189	1594	405
8-Feb-22	7.0	6369	1412	1723	311
9-Feb-22	9.3	6964	1886	1921	35
10-Feb-22	12.0	8337	2392	2304	(88)
11-Feb-22	7.6	5878	1531	1629	98
12-Feb-22	7.1	5001	1322	1415	93
13-Feb-22	7.7	5854	1575	1626	51
14-Feb-22	-	-	-	-	-
15-Feb-22	-	-	-	-	-
16-Feb-22	-	-	-	-	-
17-Feb-22	-	-	-	-	-
18-Feb-22	-	-	-	-	-
19-Feb-22	-	-	-	-	-
20-Feb-22	11.5	7127	1988	2016	28
21-Feb-22	11.3	7500	2119	2095	(24)
22-Feb-22	7.8	6345	1597	1739	143
23-Feb-22	10.7	5527	1469	1630	161
24-Feb-22	11.1	9001	2375	2432	58
25-Feb-22	8.5	7026	1737	1913	176
26-Feb-22	7.4	4804	1236	1377	141
27-Feb-22	7.9	5259	1379	1496	118
Total			**47,934**	**49,984**	**2049**

Conclusions

A total of 2,049kWh of avoided energy consumption has been measured through the analysis described above. This represents 4.3% of the energy consumed during the reporting period. Assuming a generic electricity tariff of 15c/kWh, this represents an annual cost saving of roughly $3907. Using ACT's grid emissions intensity of 0.79kg CO_2e/kWh, this ECM also delivered a carbon abatement of roughly 1.6t CO_2e.

Due to the limited amount of time elapsed since the implementation of the ECMS this report only covers a 32 day period of which there was a high cooling demand for the building. Whilst the benefits of the ECM are expected to continue, the energy avoided is not expected to remain as proportionately high during lower cooling demand periods. Preliminary projections by Exergenics have shown a 1.7% reduction in energy consumption. This report will be revisited at a later date to confirm the long term benefit of the ECMs.

Appendix 1 - Baseline Period Data

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
23-Jun-20	72	0.0	292
24-Jun-20	65	0.0	275
25-Jun-20	23	0.0	242
26-Jun-20	104	0.0	300
27-Jun-20	27	0.0	209
28-Jun-20	66	0.0	182
29-Jun-20	57	0.0	300
30-Jun-20	225	0.0	263
1-Jul-20	421	0.0	283
2-Jul-20	596	0.0	295
3-Jul-20	355	0.0	250
4-Jul-20	482	0.0	228
5-Jul-20	369	0.0	234
6-Jul-20	243	0.0	283
7-Jul-20	642	0.0	300
8-Jul-20	614	0.0	304
9-Jul-20	544	0.0	248
10-Jul-20	819	0.0	283
11-Jul-20	737	0.0	257
12-Jul-20	871	0.0	281
13-Jul-20	776	0.0	301

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
14-Jul-20	752	0.0	284
15-Jul-20	803	0.0	278
16-Jul-20	973	0.0	303
17-Jul-20	617	0.0	243
18-Jul-20	566	0.0	265
19-Jul-20	546	0.0	259
20-Jul-20	430	0.0	302
21-Jul-20	554	0.0	257
22-Jul-20	358	0.0	260
23-Jul-20	826	0.0	325
24-Jul-20	788	0.0	251
25-Jul-20	760	0.0	240
26-Jul-20	1,591	0.0	414
27-Jul-20	1,116	0.5	299
28-Jul-20	900	0.0	310
29-Jul-20	862	0.0	285
30-Jul-20	915	0.0	313
31-Jul-20	750	0.0	275
1-Aug-20	569	0.0	239
2-Aug-20	662	0.0	297
3-Aug-20	852	0.0	303
4-Aug-20	622	0.0	297
5-Aug-20	426	0.0	338

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
6-Aug-20	508	0.0	257
7-Aug-20	703	0.0	282
8-Aug-20	716	0.0	235
9-Aug-20	665	0.0	266
10-Aug-20	424	0.0	241
11-Aug-20	535	0.0	299
12-Aug-20	637	0.0	280
13-Aug-20	748	0.0	320
14-Aug-20	554	0.0	270
15-Aug-20	537	0.0	249
16-Aug-20	380	0.0	236
17-Aug-20	587	0.0	293
18-Aug-20	762	0.0	292
19-Aug-20	802	0.0	299
20-Aug-20	-	0.0	-
21-Aug-20	-	0.0	-
22-Aug-20	-	0.0	-
23-Aug-20	-	0.0	-
24-Aug-20	-	0.0	-
25-Aug-20	-	0.0	-
26-Aug-20	-	0.0	-
27-Aug-20	943	0.0	309
28-Aug-20	860	0.0	283

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
29-Aug-20	674	0.0	203
30-Aug-20	1,122	1.6	301
31-Aug-20	1,093	0.0	333
1-Sep-20	1,201	0.0	339
2-Sep-20	1,331	0.4	367
3-Sep-20	1,644	3.2	451
4-Sep-20	1,585	1.3	420
5-Sep-20	831	0.0	243
6-Sep-20	1,019	0.0	286
7-Sep-20	2,230	2.0	607
8-Sep-20	3,660	5.1	974
9-Sep-20	1,521	0.0	404
10-Sep-20	1,136	0.0	336
11-Sep-20	1,518	0.0	393
12-Sep-20	1,069	1.9	281
13-Sep-20	1,558	0.0	419
14-Sep-20	1,672	1.5	464
15-Sep-20	2,158	1.0	593
16-Sep-20	2,078	3.2	552
17-Sep-20	3,267	5.4	992
18-Sep-20	2,694	3.4	728
19-Sep-20	3,178	5.7	853
20-Sep-20	3,127	2.4	773

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
21-Sep-20	4,602	4.4	1,251
22-Sep-20	-	0.0	-
23-Sep-20	-	0.0	-
24-Sep-20	-	0.0	-
25-Sep-20	-	0.0	-
26-Sep-20	627	0.0	277
27-Sep-20	583	0.0	254
28-Sep-20	861	0.0	300
29-Sep-20	1,116	1.3	430
30-Sep-20	1,487	1.9	363
1-Oct-20	1,079	0.0	409
2-Oct-20	1,429	2.9	55
3-Oct-20	1,476	5.0	59
4-Oct-20	3,062	6.7	118
5-Oct-20	3,365	6.5	120
6-Oct-20	2,366	3.3	120
7-Oct-20	2,738	3.6	121
8-Oct-20	2,263	2.9	108
9-Oct-20	1,025	0.2	55
10-Oct-20	813	1.2	44
11-Oct-20	1,557	5.3	69
12-Oct-20	660	8.1	19
13-Oct-20	5,120	7.6	176

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
14-Oct-20	4,507	4.9	180
15-Oct-20	-	0.0	-
16-Oct-20	4,320	5.3	1,102
17-Oct-20	3,482	5.1	867
18-Oct-20	3,286	4.3	829
19-Oct-20	2,817	4.1	698
20-Oct-20	3,320	4.8	924
21-Oct-20	4,700	5.9	1,249
22-Oct-20	5,508	7.2	1,460
23-Oct-20	6,099	9.2	1,635
24-Oct-20	2,747	2.2	814
25-Oct-20	1,206	0.0	438
26-Oct-20	863	0.0	330
27-Oct-20	2,023	1.2	627
28-Oct-20	3,352	3.0	879
29-Oct-20	3,448	3.7	863
30-Oct-20	3,713	5.4	936
31-Oct-20	2,514	2.8	674
1-Nov-20	3,009	3.6	842
2-Nov-20	4,031	4.6	1,024
3-Nov-20	4,944	5.9	1,332
4-Nov-20	5,736	7.2	1,641
5-Nov-20	1,599	0.0	560

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
6-Nov-20	1,758	2.5	525
7-Nov-20	965	3.2	366
8-Nov-20	1,396	3.2	415
9-Nov-20	3,447	4.2	952
10-Nov-20	5,715	7.1	1,545
11-Nov-20	7,000	10.9	1,956
12-Nov-20	5,398	6.5	1,374
13-Nov-20	4,408	5.9	1,213
14-Nov-20	3,269	4.8	981
15-Nov-20	6,878	11.1	1,952
16-Nov-20	5,929	7.1	1,606
17-Nov-20	4,584	7.1	1,218
18-Nov-20	6,120	7.4	1,631
19-Nov-20	8,151	10.2	2,304
20-Nov-20	8,556	12.2	2,777
21-Nov-20	5,919	10.8	1,650
22-Nov-20	6,498	9.8	1,698
23-Nov-20	4,482	5.7	1,157
24-Nov-20	4,849	7.1	1,260
25-Nov-20	6,591	8.7	1,788
26-Nov-20	8,193	11.1	2,420
27-Nov-20	9,017	12.8	2,682
28-Nov-20	8,056	15.1	2,369

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
29-Nov-20	5,219	9.4	1,466
30-Nov-20	5,633	7.2	1,495
1-Dec-20	8,409	12.1	2,510
2-Dec-20	5,570	7.5	1,492
3-Dec-20	5,590	6.0	1,522
4-Dec-20	5,811	9.0	1,714
5-Dec-20	4,198	8.7	1,213
6-Dec-20	2,487	3.8	739
7-Dec-20	2,900	2.6	827
8-Dec-20	2,978	2.8	818
9-Dec-20	4,554	6.4	1,249
10-Dec-20	4,548	7.0	1,209
11-Dec-20	2,218	4.2	659
12-Dec-20	2,021	4.4	618
13-Dec-20	3,514	7.0	1,048
14-Dec-20	5,454	8.8	1,488
15-Dec-20	8,738	11.3	2,337
16-Dec-20	9,578	11.1	2,566
17-Dec-20	10,349	12.4	2,975
18-Dec-20	6,593	9.1	1,894
19-Dec-20	3,131	6.0	930
20-Dec-20	4,798	9.7	1,372
21-Dec-20	4,584	6.4	1,212

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
22-Dec-20	2,617	3.8	991
23-Dec-20	2,712	6.3	1,221
24-Dec-20	3,947	8.9	1,406
25-Dec-20	2,816	5.7	849
26-Dec-20	4,208	8.0	1,236
27-Dec-20	7,283	13.4	2,140
28-Dec-20	5,264	10.5	1,503
29-Dec-20	3,593	6.9	1,025
30-Dec-20	4,531	8.4	1,258
31-Dec-20	3,761	7.9	1,088
1-Jan-21	2,543	5.5	799
2-Jan-21	3,355	6.8	1,000
3-Jan-21	5,058	8.6	1,436
4-Jan-21	5,054	8.0	1,374
5-Jan-21	6,149	9.3	1,742
6-Jan-21	3,997	6.7	1,095
7-Jan-21	3,735	5.9	1,035
8-Jan-21	3,107	4.8	908
9-Jan-21	4,749	9.0	1,385
10-Jan-21	6,276	11.2	1,828
11-Jan-21	8,654	12.1	2,640
12-Jan-21	9,910	12.8	2,945
13-Jan-21	11,732	14.6	3,603

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
14-Jan-21	9,266	11.6	2,822
15-Jan-21	5,708	7.0	1,594
16-Jan-21	3,132	4.4	934
17-Jan-21	4,442	7.4	1,284
18-Jan-21	7,124	10.6	2,089
19-Jan-21	5,431	9.9	1,550
20-Jan-21	2,639	6.3	1,298
21-Jan-21	3,675	10.4	2,029
22-Jan-21	5,582	12.7	2,704
23-Jan-21	7,812	14.8	2,429
24-Jan-21	10,107	15.6	3,155
25-Jan-21	12,857	17.5	4,468
26-Jan-21	8,275	12.1	2,341
27-Jan-21	5,587	7.0	1,336
28-Jan-21	4,534	4.3	1,012
29-Jan-21	5,721	6.9	1,337
30-Jan-21	6,674	11.7	1,746
31-Jan-21	5,239	8.9	1,341
1-Feb-21	7,356	9.5	1,904
2-Feb-21	5,239	7.5	1,315
3-Feb-21	5,940	7.8	1,494
4-Feb-21	8,548	11.5	2,262
5-Feb-21	9,017	10.1	2,312

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
6-Feb-21	4,901	7.3	1,302
7-Feb-21	5,585	9.5	1,453
8-Feb-21	5,830	8.6	1,452
9-Feb-21	4,687	7.4	1,193
10-Feb-21	5,349	8.2	1,400
11-Feb-21	7,663	11.6	2,132
12-Feb-21	7,067	10.4	1,815
13-Feb-21	3,908	8.8	1,117
14-Feb-21	4,042	8.0	1,143
15-Feb-21	5,150	7.3	1,363
16-Feb-21	5,865	8.4	1,543
17-Feb-21	4,719	7.8	1,252
18-Feb-21	5,363	7.8	1,401
19-Feb-21	6,337	9.4	1,721
20-Feb-21	6,750	12.0	1,934
21-Feb-21	6,228	11.6	1,676
22-Feb-21	7,390	10.3	2,128
23-Feb-21	3,978	5.5	1,039
24-Feb-21	4,210	5.4	1,105
25-Feb-21	5,268	6.2	1,394
26-Feb-21	5,459	8.8	1,509
27-Feb-21	4,044	7.6	1,221
28-Feb-21	5,237	9.5	1,506

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
1-Mar-21	6,237	8.6	1,806
2-Mar-21	3,582	6.6	986
3-Mar-21	2,874	5.6	807
4-Mar-21	5,256	6.7	1,473
5-Mar-21	4,190	7.0	1,188
6-Mar-21	2,117	5.3	675
7-Mar-21	4,390	8.8	1,259
8-Mar-21	5,175	7.6	1,440
9-Mar-21	6,129	9.6	1,694
10-Mar-21	6,195	9.8	1,677
11-Mar-21	5,808	9.3	1,531
12-Mar-21	6,343	9.3	1,785
13-Mar-21	5,969	8.2	1,754
14-Mar-21	2,156	0.0	702
15-Mar-21	2,642	4.4	750
16-Mar-21	3,611	5.7	1,019
17-Mar-21	3,358	5.2	957
18-Mar-21	4,166	6.9	1,164
19-Mar-21	3,721	6.7	1,042
20-Mar-21	3,064	6.5	949
21-Mar-21	3,230	5.0	954
22-Mar-21	3,691	4.4	998
23-Mar-21	4,172	5.7	1,133

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
24-Mar-21	3,779	5.5	1,051
25-Mar-21	3,840	3.5	1,096
26-Mar-21	3,484	4.1	990
27-Mar-21	2,758	3.2	863
28-Mar-21	1,540	2.6	504
29-Mar-21	3,300	5.6	931
30-Mar-21	2,094	3.1	617
31-Mar-21	2,969	4.6	878
1-Apr-21	4,522	6.4	1,228
2-Apr-21	4,817	7.7	1,364
3-Apr-21	3,973	7.3	1,175
4-Apr-21	4,717	8.4	1,326
5-Apr-21	5,746	8.8	1,559
6-Apr-21	5,552	7.6	1,529
7-Apr-21	4,888	6.9	1,304
8-Apr-21	5,213	7.7	1,405
9-Apr-21	3,927	4.7	1,109
10-Apr-21	695	0.0	281
11-Apr-21	589	0.0	249
12-Apr-21	1,150	0.0	397
13-Apr-21	1,470	3.4	460
14-Apr-21	1,860	2.7	560
15-Apr-21	1,687	0.9	520

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
16-Apr-21	1,369	1.8	449
17-Apr-21	782	1.8	306
18-Apr-21	714	0.0	277
19-Apr-21	1,074	0.9	426
20-Apr-21	905	0.2	440
21-Apr-21	624	0.0	352
22-Apr-21	513	0.0	319
23-Apr-21	538	0.0	320
24-Apr-21	344	0.0	234
25-Apr-21	406	0.0	254
26-Apr-21	998	0.0	355
27-Apr-21	1,391	3.0	430
28-Apr-21	1,903	1.3	556
29-Apr-21	1,644	2.4	534
30-Apr-21	2,112	3.3	641
1-May-21	1,926	2.8	661
2-May-21	2,510	2.5	777
3-May-21	3,321	4.5	925
4-May-21	2,427	1.3	701
5-May-21	2,671	3.8	798
6-May-21	3,249	5.4	943
7-May-21	3,461	4.2	961
8-May-21	2,274	2.4	735

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
9-May-21	2,301	1.4	742
10-May-21	2,778	2.3	826
11-May-21	2,359	0.4	735
12-May-21	2,201	0.4	655
13-May-21	1,153	1.1	392
14-May-21	845	0.0	317
15-May-21	783	0.0	342
16-May-21	349	0.0	248
17-May-21	762	0.0	273
18-May-21	727	0.0	297
19-May-21	570	0.0	294
20-May-21	753	0.0	315
21-May-21	682	0.0	266
22-May-21	526	0.0	217
23-May-21	608	0.9	255
24-May-21	869	0.0	479
25-May-21	810	1.8	457
26-May-21	427	0.0	279
27-May-21	449	0.0	284
28-May-21	392	0.0	240
29-May-21	327	0.0	220
30-May-21	291	0.0	260
31-May-21	398	0.0	301

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
1-Jun-21	431	0.0	292
2-Jun-21	778	0.0	308
3-Jun-21	1,048	0.0	384
4-Jun-21	942	0.0	335
5-Jun-21	567	0.0	240
6-Jun-21	609	0.0	245
7-Jun-21	800	0.0	296
8-Jun-21	651	0.0	252
9-Jun-21	757	0.0	329
10-Jun-21	712	0.0	276
11-Jun-21	683	0.0	270
12-Jun-21	541	0.0	236
13-Jun-21	639	0.0	252
14-Jun-21	683	0.0	284
15-Jun-21	779	0.0	287
16-Jun-21	672	0.0	269
17-Jun-21	839	0.0	337
18-Jun-21	646	0.0	281
19-Jun-21	592	0.0	237
20-Jun-21	600	0.0	261
21-Jun-21	816	0.0	286
22-Jun-21	795	0.0	301
23-Jun-21	1,028	0.0	398

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
24-Jun-21	1,646	0.0	549
25-Jun-21	813	0.0	316
26-Jun-21	578	0.0	247
27-Jun-21	547	0.0	252
28-Jun-21	636	0.0	263
29-Jun-21	896	0.0	325
30-Jun-21	858	0.0	305
1-Jul-21	935	0.0	359
2-Jul-21	917	0.0	342
3-Jul-21	415	0.0	225
4-Jul-21	455	0.0	220
5-Jul-21	741	0.0	347
6-Jul-21	859	0.0	364
7-Jul-21	682	0.0	309
8-Jul-21	864	0.0	327
9-Jul-21	747	0.0	297
10-Jul-21	439	0.0	210
11-Jul-21	623	0.0	252
12-Jul-21	880	0.0	315
13-Jul-21	840	0.0	287
14-Jul-21	786	0.0	317
15-Jul-21	895	0.0	314
16-Jul-21	591	0.0	252

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
17-Jul-21	595	0.0	268
18-Jul-21	617	0.0	275
19-Jul-21	728	0.0	303
20-Jul-21	634	0.0	298
21-Jul-21	970	0.0	383
22-Jul-21	550	0.0	271
23-Jul-21	689	0.0	309
24-Jul-21	355	0.0	183
25-Jul-21	629	0.0	276
26-Jul-21	762	0.0	306
27-Jul-21	816	0.0	292
28-Jul-21	740	0.0	304
29-Jul-21	921	0.0	349
30-Jul-21	766	0.0	303
31-Jul-21	562	0.0	235
1-Aug-21	617	0.0	275
2-Aug-21	674	0.0	271
3-Aug-21	657	0.0	279
4-Aug-21	813	0.0	312
5-Aug-21	775	0.0	292
6-Aug-21	758	0.0	300
7-Aug-21	340	0.0	197
8-Aug-21	812	0.0	292

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
9-Aug-21	650	0.0	260
10-Aug-21	890	0.0	297
11-Aug-21	1,282	0.4	413
12-Aug-21	890	0.0	346
13-Aug-21	768	0.0	295
14-Aug-21	641	0.0	269
15-Aug-21	698	0.0	258
16-Aug-21	742	0.0	287
17-Aug-21	644	0.0	263
18-Aug-21	731	0.0	273
19-Aug-21	737	0.0	281
20-Aug-21	877	0.4	292
21-Aug-21	615	0.0	243
22-Aug-21	827	2.9	291
23-Aug-21	1,304	0.7	403
24-Aug-21	798	0.0	302
25-Aug-21	690	0.0	277
26-Aug-21	740	0.0	268
27-Aug-21	687	0.0	268
28-Aug-21	641	0.0	229
29-Aug-21	602	0.0	258
30-Aug-21	542	0.0	227
31-Aug-21	916	0.0	307

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
1-Sep-21	1,647	2.1	519
2-Sep-21	2,112	4.0	643
3-Sep-21	2,917	4.2	838
4-Sep-21	1,812	0.0	574
5-Sep-21	650	0.0	270
6-Sep-21	850	0.0	308
7-Sep-21	931	0.0	329
8-Sep-21	756	0.0	285
9-Sep-21	1,016	3.6	342
10-Sep-21	1,568	1.8	485
11-Sep-21	1,308	5.4	419
12-Sep-21	679	0.0	270
13-Sep-21	404	0.0	273
14-Sep-21	355	0.0	230
15-Sep-21	429	0.5	276
16-Sep-21	391	0.0	263
17-Sep-21	1,273	3.2	458
18-Sep-21	901	0.0	316
19-Sep-21	597	0.2	247
20-Sep-21	711	0.0	281
21-Sep-21	729	0.0	278
22-Sep-21	851	0.0	314
23-Sep-21	1,058	1.9	352

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
24-Sep-21	1,046	2.2	363
25-Sep-21	589	0.0	238
26-Sep-21	591	0.0	235
27-Sep-21	923	0.3	322
28-Sep-21	1,716	3.8	513
29-Sep-21	2,483	1.1	717
30-Sep-21	2,334	0.9	724
1-Oct-21	2,592	3.2	746
2-Oct-21	2,299	1.5	714
3-Oct-21	2,478	2.6	740
4-Oct-21	1,229	1.8	407
5-Oct-21	777	0.0	292
6-Oct-21	1,314	1.5	400
7-Oct-21	1,557	1.4	491
8-Oct-21	1,181	0.5	386
9-Oct-21	1,618	4.9	489
10-Oct-21	2,198	2.6	641
11-Oct-21	703	1.3	272
12-Oct-21	921	0.2	308
13-Oct-21	1,852	0.8	590
14-Oct-21	2,026	0.8	599
15-Oct-21	880	0.0	287
16-Oct-21	699	0.0	251

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
17-Oct-21	1,005	0.2	311
18-Oct-21	2,242	4.7	650
19-Oct-21	1,087	2.1	337
20-Oct-21	2,618	2.5	738
21-Oct-21	3,124	5.0	908
22-Oct-21	2,055	5.1	1,021
23-Oct-21	1,738	4.8	926
24-Oct-21	461	1.5	301
25-Oct-21	783	0.0	441
26-Oct-21	1,228	3.0	550
27-Oct-21	2,875	4.7	799
28-Oct-21	4,032	8.0	1,124
29-Oct-21	1,901	1.5	511
30-Oct-21	963	0.0	317
31-Oct-21	1,511	2.3	413
1-Nov-21	3,293	4.5	915
2-Nov-21	4,682	5.6	1,248
3-Nov-21	5,175	7.4	1,391
4-Nov-21	3,571	3.4	957
5-Nov-21	3,584	4.2	954
6-Nov-21	4,071	6.4	1,143
7-Nov-21	4,713	8.3	1,297
8-Nov-21	5,077	7.8	1,373

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
9-Nov-21	4,181	7.0	1,106
10-Nov-21	4,228	3.9	1,094
11-Nov-21	3,482	4.5	1,051
12-Nov-21	2,657	0.3	778
13-Nov-21	1,700	0.0	501
14-Nov-21	821	0.0	273
15-Nov-21	970	0.0	297
16-Nov-21	1,464	1.5	395
17-Nov-21	2,126	2.8	547
18-Nov-21	3,323	7.4	862
19-Nov-21	4,468	7.3	1,126
20-Nov-21	2,775	2.5	772
21-Nov-21	1,858	1.2	539
22-Nov-21	1,621	2.9	448
23-Nov-21	4,447	6.5	1,170
24-Nov-21	5,640	8.0	1,359
25-Nov-21	5,083	6.4	1,249
26-Nov-21	2,471	1.0	742
27-Nov-21	1,241	0.3	380
28-Nov-21	1,001	1.2	290
29-Nov-21	4,895	5.7	1,210
30-Nov-21	7,146	9.2	1,885
1-Dec-21	6,768	7.7	1,729

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
2-Dec-21	7,950	10.1	2,185
3-Dec-21	7,792	10.4	2,278
4-Dec-21	3,951	7.3	1,082
5-Dec-21	2,172	1.6	626
6-Dec-21	4,070	4.9	1,052
7-Dec-21	6,108	7.7	1,562
8-Dec-21	3,763	4.1	955
9-Dec-21	2,629	4.2	892
10-Dec-21	1,098	2.4	497
11-Dec-21	824	3.8	425
12-Dec-21	1,562	5.2	766
13-Dec-21	3,190	7.5	1,620
14-Dec-21	4,096	9.2	1,999
15-Dec-21	4,105	10.6	1,965
16-Dec-21	3,112	8.4	1,466
17-Dec-21	3,707	9.8	1,934
18-Dec-21	5,721	10.6	1,853
19-Dec-21	3,885	6.1	1,068
20-Dec-21	6,158	6.3	1,667
21-Dec-21	7,927	9.8	2,308
22-Dec-21	8,119	11.7	2,438
23-Dec-21	7,804	11.3	2,196
24-Dec-21	7,839	11.6	2,161

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
25-Dec-21	6,326	11.6	1,805
26-Dec-21	4,124	7.5	1,129
27-Dec-21	2,790	2.7	782
28-Dec-21	1,814	2.6	519
29-Dec-21	4,750	7.6	1,300
30-Dec-21	6,963	9.8	1,967
31-Dec-21	6,956	10.9	2,094
1-Jan-22	7,370	7.9	2,128
2-Jan-22	8,387	13.5	2,428
3-Jan-22	8,348	10.9	2,316
4-Jan-22	8,319	10.0	2,279
5-Jan-22	8,706	10.8	2,298
6-Jan-22	8,956	10.3	2,424
7-Jan-22	6,472	7.4	1,599
8-Jan-22	5,913	11.3	1,633
9-Jan-22	7,399	10.7	1,925
10-Jan-22	11,575	14.0	3,427
11-Jan-22	8,688	9.9	2,280
12-Jan-22	7,498	10.7	2,040
13-Jan-22	7,496	9.8	1,960
14-Jan-22	7,845	10.9	2,124
15-Jan-22	6,162	10.1	1,697
16-Jan-22	7,961	11.7	2,213

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
17-Jan-22	8,619	11.6	2,285
18-Jan-22	5,116	6.4	1,261
19-Jan-22	3,947	7.0	1,054
20-Jan-22	3,642	5.4	964
21-Jan-22	4,344	5.8	1,168
22-Jan-22	4,173	7.1	1,159
23-Jan-22	5,183	8.1	1,396
24-Jan-22	6,545	9.3	1,726

Appendix 2 - Reporting Period Data

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
26-Jan-22	6307	8.9	1661
27-Jan-22	9787	11.1	2661
28-Jan-22	11883	12.4	3179
29-Jan-22	7175	10.5	1823
30-Jan-22	8466	10.4	2198
31-Jan-22	9756	10.7	2658
1-Feb-22	11377	12.2	3194
2-Feb-22	5191	6.2	1321
3-Feb-22	4605	5.9	1204
4-Feb-22	3609	5.4	981
5-Feb-22	3119	5.7	913
6-Feb-22	3279	4.9	938
7-Feb-22	5924	5.9	1189
8-Feb-22	6369	7.0	1412
9-Feb-22	6964	9.3	1886
10-Feb-22	8337	12.0	2392
11-Feb-22	5878	7.6	1531
12-Feb-22	5001	7.1	1322
13-Feb-22	5854	7.7	1575
14-Feb-22	6192	10.8	2283
15-Feb-22	4880	12.1	2668

Date	Cooling Demand (kWrh)	CDD	Actual Energy Consumption (kWh)
16-Feb-22	4469	7.4	2447
17-Feb-22	4652	10.7	2404
18-Feb-22	3677	10.3	1978
19-Feb-22	3651	4.8	1296
20-Feb-22	7127	11.5	1988
21-Feb-22	7500	11.3	2119
22-Feb-22	6345	7.8	1597
23-Feb-22	5527	10.7	1469
24-Feb-22	9001	11.1	2375
25-Feb-22	7026	8.5	1737
26-Feb-22	4804	7.4	1236
27-Feb-22	5259	7.9	1379