ACHIEVING ENERGY SAVINGS THROUGH ANALYTICS - THE CSIRO HIGH RESOLUTION PLANT PHENOMICS CENTRE

OVERVIEW

The High Resolution Plant Phenomics Centre (HRPPC) Phytotron is a two storey, 3120m^2 research laboratory located at the CSIRO Black Mountain facility in Canberra, Australia. A phytotron is a building in which plants can be grown in controlled climatic conditions and combines glasshouses and controlled environment cabinets. The building was constructed in 1962 and has undergone several refurbishments since. Although the HVAC system was meeting occupant comfort and equipment environment requirements there was considered to be an opportunity for a Fault Detection and Diagnostics (FDD) tool to identify equipment inefficiencies and potential energy savings. Control & Electric was given the opportunity to implement SkySpark® Analytics by SkyFoundry for the HRPPC in May 2016 as part of a 12 month FDD program. This case study provides an overview of the project and final results.

Figure 1 High Resolution Plant Phenomics Centre - Canberra, Australia (Credit: CSIRO)

SITE INFORMATION

- 24 hour research laboratories
- Annual energy consumption ≈2700 MWh
- 15 greenhouses
- 100+ refrigerated cabinets
- 10 air handling units, 2 fan coil units
- Wide range of seasonal temperatures in local region*

*Degree days are a measure of the number of degrees above or below the base comfort temperature of a building. E.g. with a base temperature of 21°C, a day with an average temperature of 35°C is calculated to be a 14°C cooling degree day. Normalising the energy usage against the number of degree days enables a fair comparison of data from multiple years. However in climates such as Canberra where it is common to have cold mornings and warm afternoon temperatures, using the daily average temperature in a degree day calculation will not provide an accurate representation of the heating and cooling required for that day. In this report the degree day energy normalisation has used 'totalised' degree days (see Appendix).

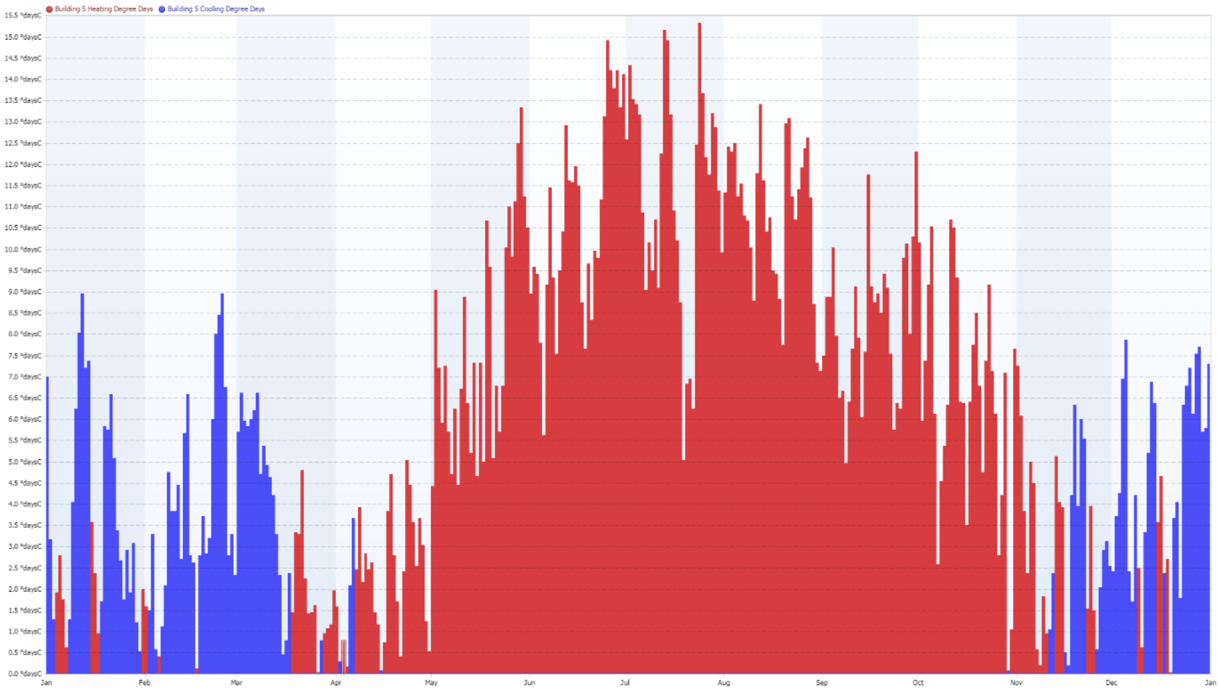

Figure 2 Heating (red) and cooling (blue) degree days for Canberra in 2016

APPROACH

A data connection was configured from the Siemens APOGEE Building Automation System (BAS) to SkySpark to provide near real time data which is continuously compared against a custom suite of fault detection rules developed by the Control & Electric Energy Monitoring team. These algorithms analyse the data for 'sparks' or any patterns or outliers that would indicate faults such as simultaneous heating and cooling, excessive cycling and rapid rates of change as well as temperature and humidity instability.

Any faults identified by the energy team are communicated to service personnel via the SkySpark Notes application who can then perform follow up investigations or repairs on site.

Monthly reports are delivered to the facility manager to highlight the issues identified and resolved during that period and any required actions. Each issue is summarised and assigned a severity rating, recommended actions, maintenance outcome, estimated cost with energy savings and repair progress status.

RESULTS

After twelve months of analysis, SkySpark has been able to identify several opportunities for improvements by alerting the energy team to the following issues:

- simultaneous heating and cooling
- valves staying open excessively
- valves cycling excessively
- temperature instability
- heating call threshold mismatch between control of HHW pumps and valves
- public holidays are not scheduled in the BMS
- unstable dehumidification control

Examples of some of the issues are shown below along with historical site energy data and current savings. The connection of a gas meter in early July 2016 gave an important insight into the gas consumption patterns and equipment operation (see Figure 3).

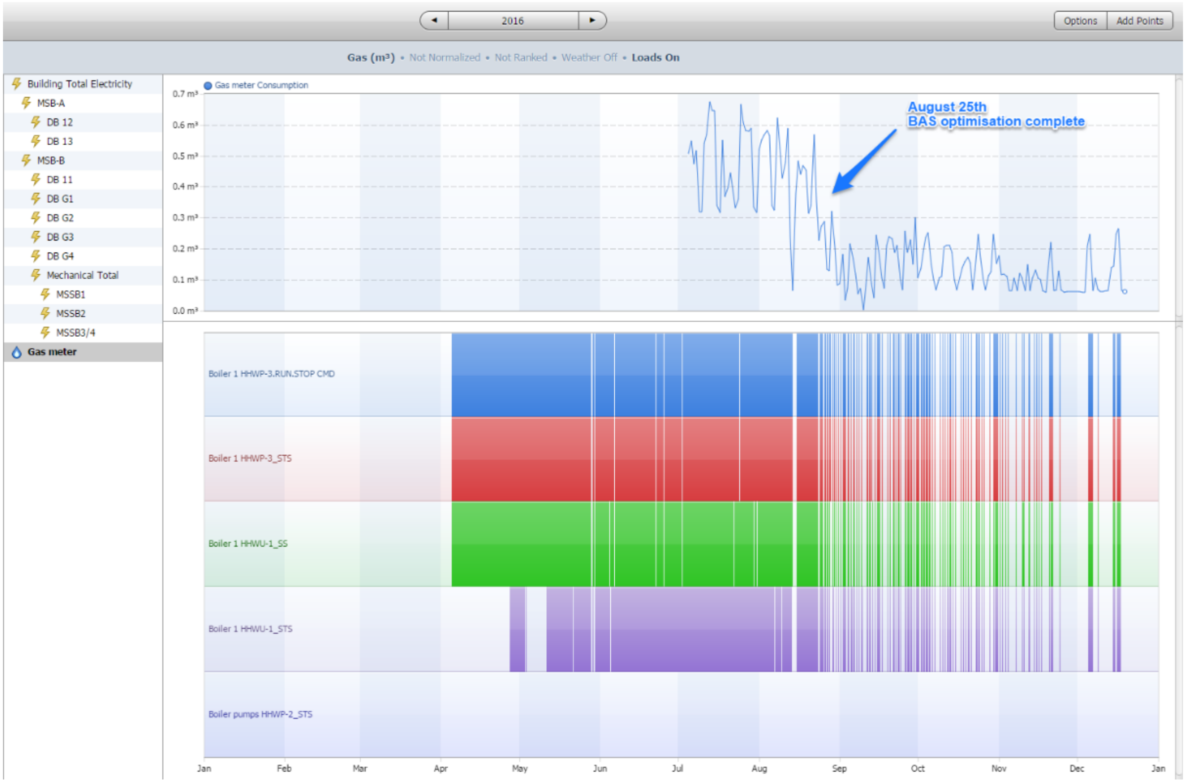

Figure 3 Gas consumption profile and equipment loads

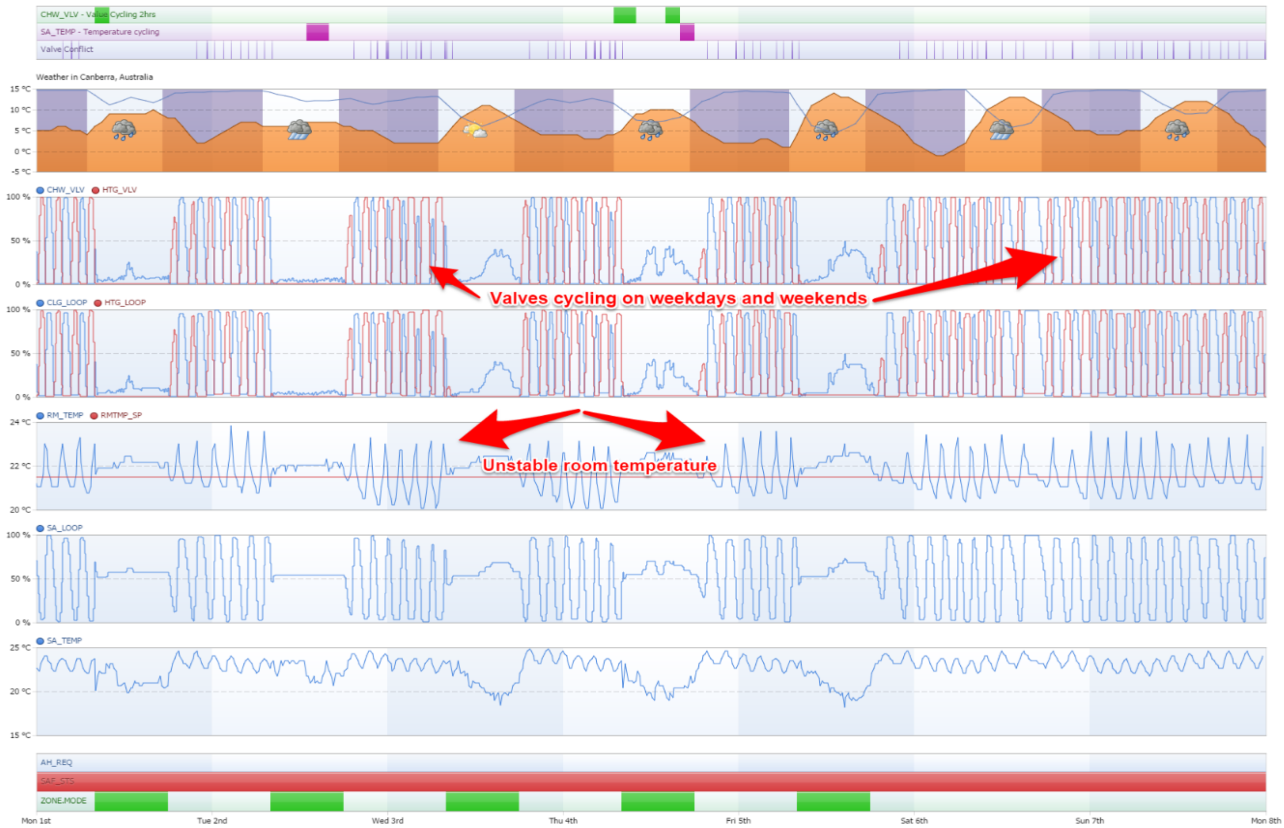

Figure 4 AHU 1-3 faults shown in Site Spark application

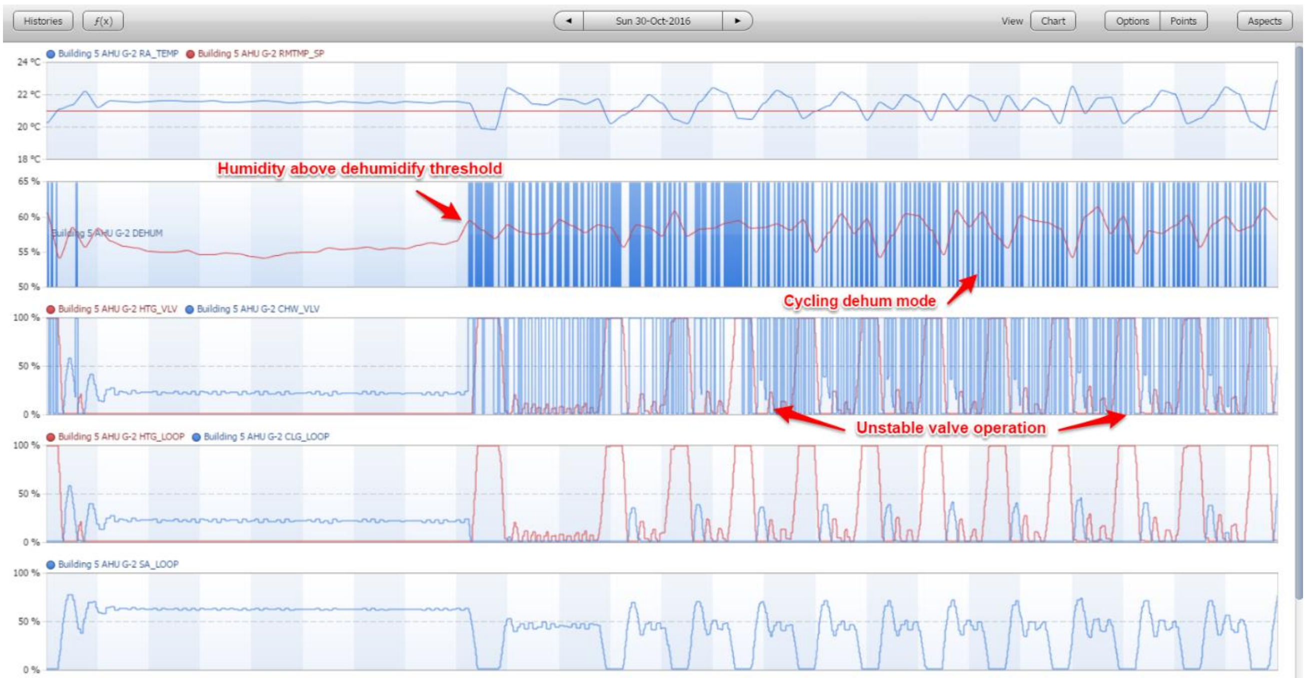

Figure 5 Unstable dehumidification mode on AHU G-2

Figure 6 Building 5 Energy consumption 2016

Figure 7 CO2 emissions (combined gas/electrical data available 07/2016)

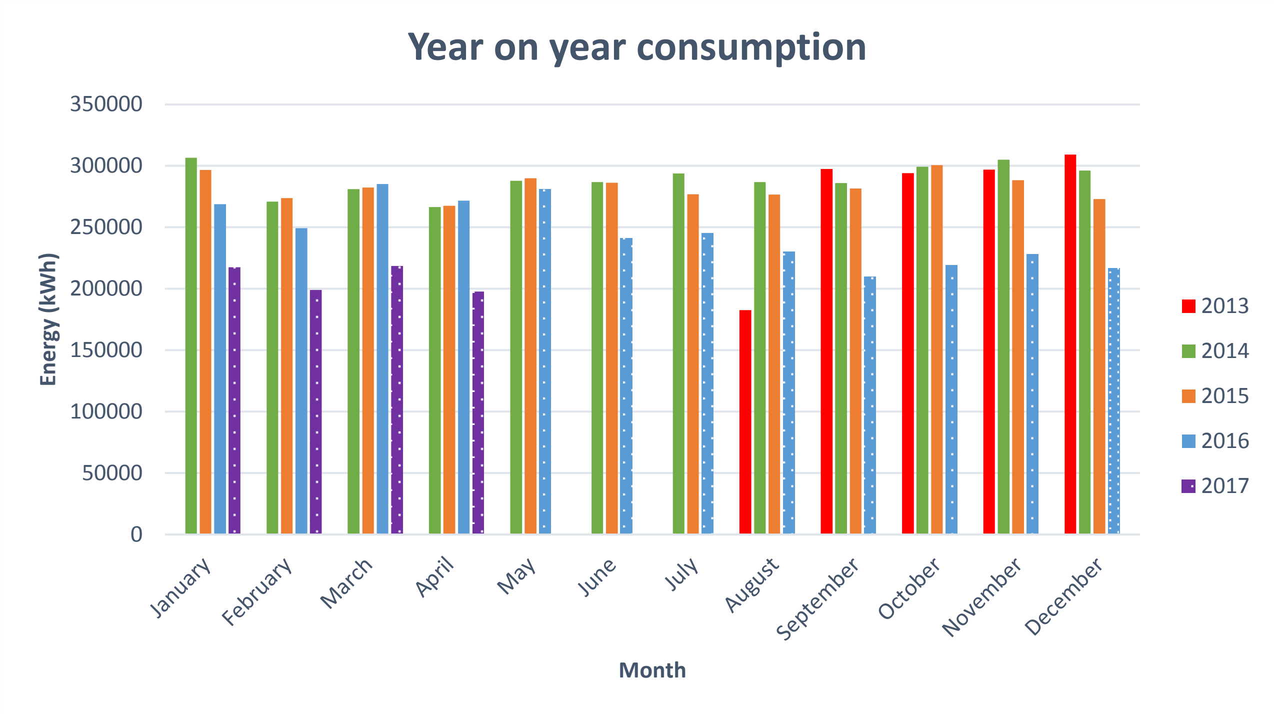

Figure 8 Building 5 total energy consumption (patterned bars indicate SkySpark monitoring active)

Date	% Difference 2017 vs 2015	% Difference 2016 vs 2015	2017	2016	2015	2014	2013
January	-18.4	-10.1	216,949	265,987	296,002	211,929	
February	-22.1	-6.6	198,245	254,605	272,662	276,044	
March	-23.6	-0.9	218,486	286,050	288,771	283,157	
April	-27.2	+2.3	197,798	271,686	265,464	265,522	
May		-5.7		268,540	284,750	286,178	
June		-16.2		242,184	289,068	285,271	
July		-12.6		245,243	280,680	295,886	
August		-15.0		233,332	274,639	287,204	184,863
September		-24.4		210,547	278,423	283,361	297,399
October		-28.0		217,304	301,734	298,881	294,165
November		-21.5		226,821	289,035	302,687	296,910
December		-21.7		220,642	281,704	300,774	300,351
Total				2,942,941	3,402,932	3376894	

Table 1 Building 5 total energy consumption (shaded cells indicate SkySpark monitoring active)

ENERGY NORMALISATION

In order to validate the apparent energy savings since the commencement of the FDD trial the energy data was normalised against totalised degree days (Figure 9) and a comparison drawn between the average monthly consumption profiles since 2013 (Figure 10). The degree day normalisation allows the comparison of energy data by minimising the influence of varied weather conditions (see Appendix for the totalised degree day method used).

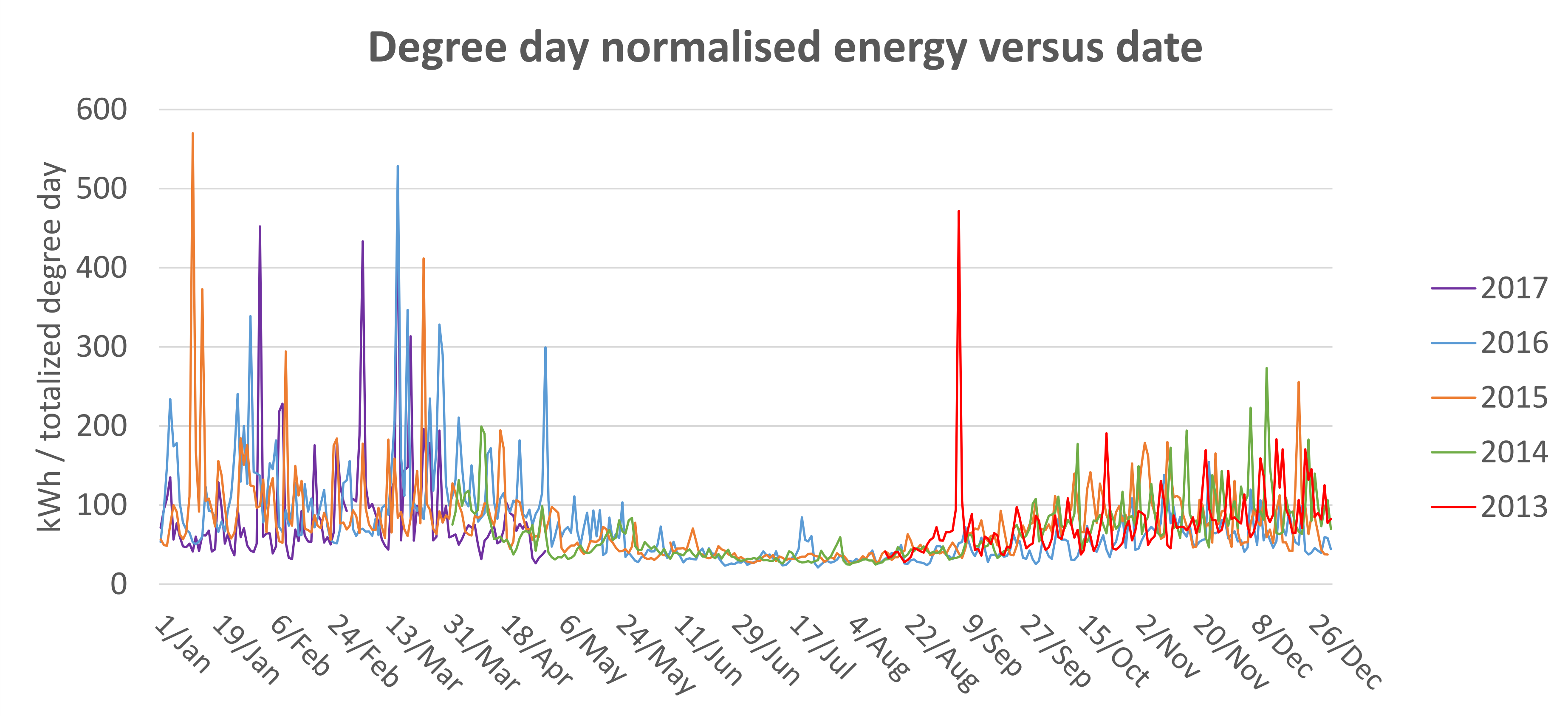

Figure 9 Totalised degree days versus date (compiled May 2017)

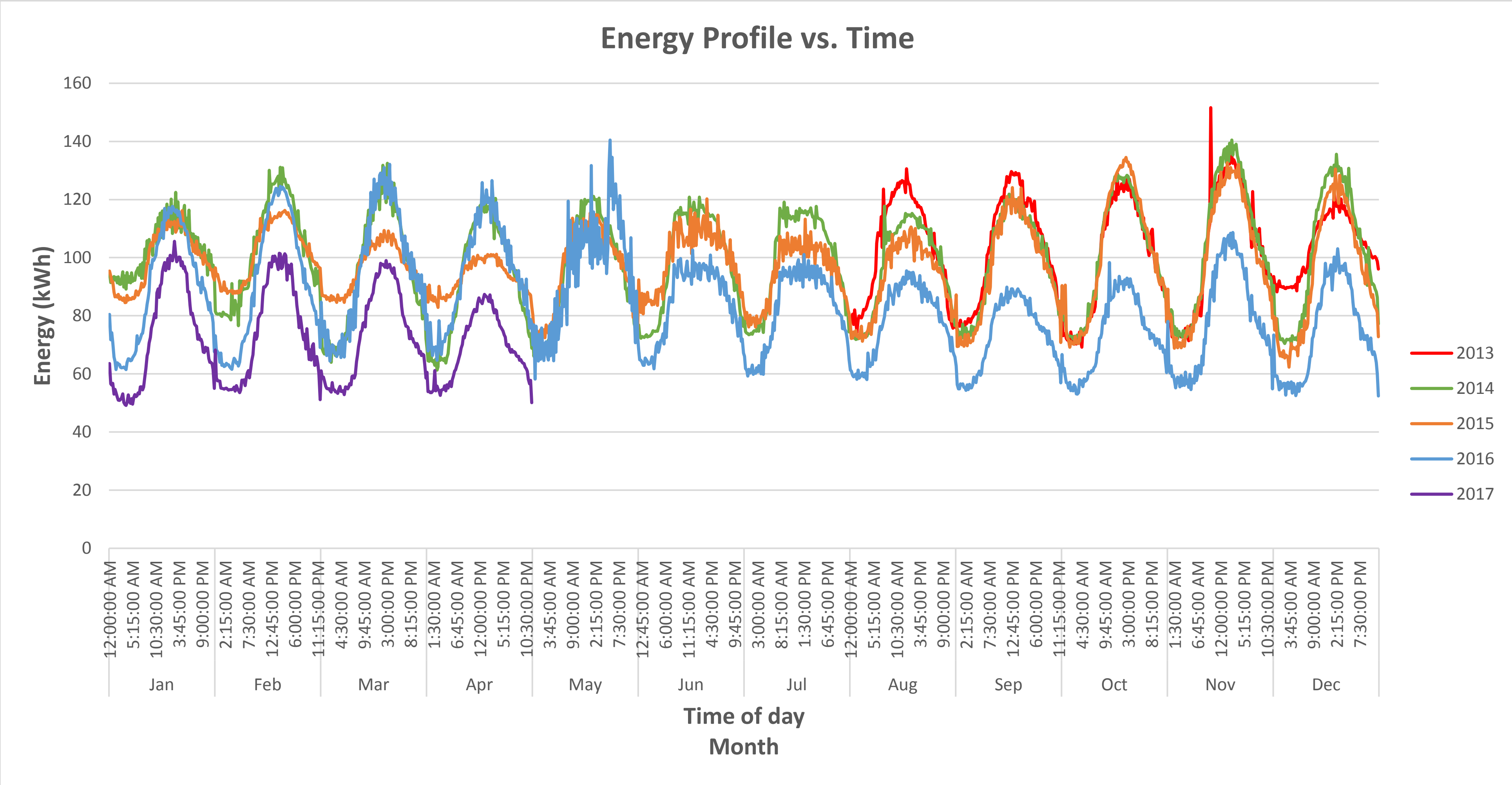

Figure 10 Energy profile versus time (compiled May 2017)

SUMMARY

Over the course of the twelve month trial there has been a significant improvement in building performance and a 20% average reduction in monthly energy consumption. This demonstrates the value of monitoring based commissioning due to the large energy and operational savings. Using SkySpark to monitor the HVAC performance allowed engineers to quickly and easily identify operational issues and faults. These issues were then effectively communicated to facility managers and service personnel in order to undertake repairs or controls tuning. Whilst these issues often had little to no measureable effect on the interior conditions and comfort of the building; such inefficiencies are detrimental to equipment lifetime and overall building energy performance. It is likely that without automated analytics these issues may otherwise have been lost in the sheer amount of data generated by a modern BAS.

Ongoing monitoring will continue to ensure these savings are maintained and any new issues can be quickly identified and corrected before they have a large impact on energy performance. The use of automated analytics allows building operators and facility managers to gain valuable insight from the raw BAS data. Reviewing the data in SkySpark allows multiple streams of data to be correlated in a single visualisation. This integrated view saves the operator time and can serve to identify new faults that can only be seen by correlating data from multiple sensors and equipment. New rules can then be added to the SkySpark rule database to catch recurring instances.

APPENDIX – TOTALISED DEGREE DAY CALCULATIONS

Average daily temperature degree days do not accurately account for the range of temperatures and morning heating/afternoon cooling load that is common to Canberra’s climate. As such this report has normalised the energy data using average hourly temperatures rather than using a single daily average temperature for the degree day calculation. The following process was used:

1. The average hourly outside temperature is compared to the chosen heating and cooling bases (17°C and 19°C respectively).
2. If the outside temperature is lower than 17°C, the difference between the outside temperature and heating base is calculated and assigned to that 60 minute period. Vice versa for temperatures warmer than the cooling base. Any temperatures in between the bases receive a value of zero (this implies there was a minimum requirement for heating or cooling for that hour).
3. The heating and cooling values are added to generate a single ‘totalised’ degree day value for that day.
4. The daily energy usage is then divided by this value.