Aotearoa Park Shopping Centre

Sample Type 2 Energy Audit

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EXECUTIVE SUMMARY

This report presents an energy audit for Aotearoa Park Shopping Centre for Aotearoa Park Ltd. The findings of this report are based upon a Type 2 energy audit, compliant with the requirement of AS/NZS3598.1:2014. This report was commissioned by Hone Smith, the building manager for the site.

The audit period in this study is from 01/06/2013 to 31/05/2014, with site work undertaken from 26/6/2014-1/7/2014. This audit is limited to the base building services for the site, comprising common area air-conditioning and lighting, car park services, and the central condenser water loop servicing the tenant water cooled package units (which are outside the scope of the audit). The base building electricity consumption for the shopping centre was 929,370 kWh p.a. at an approximate cost of $85,000 and the gas consumption for the shopping centre was 692,393 MJ p.a. at a cost of $9,600.

While there are no local comparative indicators of performance, comparison against the Australian NABERS for Shopping Centres indicates average performance. Implementation of all measures in this report would move the estimated rating to the upper end of the performance scale.

The following key opportunities for the improvement of the building's energy performance have been identified through our site visit and subsequent investigation:

- Common area zone temperature control
- Condensing water loop control
- Mall lighting upgrade
- Mall lighting re-circuit
- Electricity and water end use sub-metering

Successful implementation of the identified upgrade opportunities has the ability to achieve annual savings of approximately 340,000 kWh of electricity (36%), calculated using averaged time of use rates plus separately evaluated demand. Annual energy cost savings are expected to be approximately $31,000 and the total cost for the proposed base building measures is approximately $241,000. On an incremental basis the upgrade has a payback of 7.8 years. Savings have been assessed to a medium level of accuracy, meeting the requirements for a Type 2 audit. A further capital cost of approximate $2m has been identified in relation to the end-of-life replacement of the tenancy package units.

A summary of measures is provided in Table 1. The expected improvement to the end-use electricity consumption of each building sub-systems is shown in Figure 1. All dollar figures in this report exclude GST.

Measure	Annual Electricity Savings	Total Annual Financial Savings ($)	Total Project Cost ($)	Payback year
Shorter Payback Measures (up to 5 years)				
Common zone temp control	33,000 kWh	3,000	1,100	0.4
Primary condensing water loop control	7,600 kWh 93 GJ (gas)	2,000	5,800	2.9
Mall lighting upgrade	130,000 kWh	12,000	50,000	4.2
Skylight pelmet lighting upgrade and control	33,000 kWh	3,000	14,000	4.7
Longer Payback Measures (5 years+)				
Pendant Mercury light replacement	21,000 kWh	1,900	12,000	6.3
Security lighting re-circuit	51,000 kWh	3,500	30,000	8.6
Back of house lighting upgrade	4,700 kWh	400	3,700	9.3
Secondary condensing water loop control	61,000 kWh	6,800	120,000	18.0
Toilet lighting upgrade	1,000 kWh	100	4,800	48.0
Tenant package units life cycle replacement	N.A.	N.A.	2,010,000	N.A.
Energy Management Measures				
Energy Management Program Enhancements	N.A.	N.A.	N.A.	N.A.
Energy and Water Sub-metering	N.A.	N.A.	82,000	N.A.
Sub-total	**342,000**	**31,400**	**241,000***	**7.8***

Table 1 Energy saving measures summary. Note that Aotearoa Park Ltd asked for the 4 year payback threshold identified in the Standard to be extended to 5 years.

*** this figure does not include the tenant package unit life cycle replacement capital figure.**

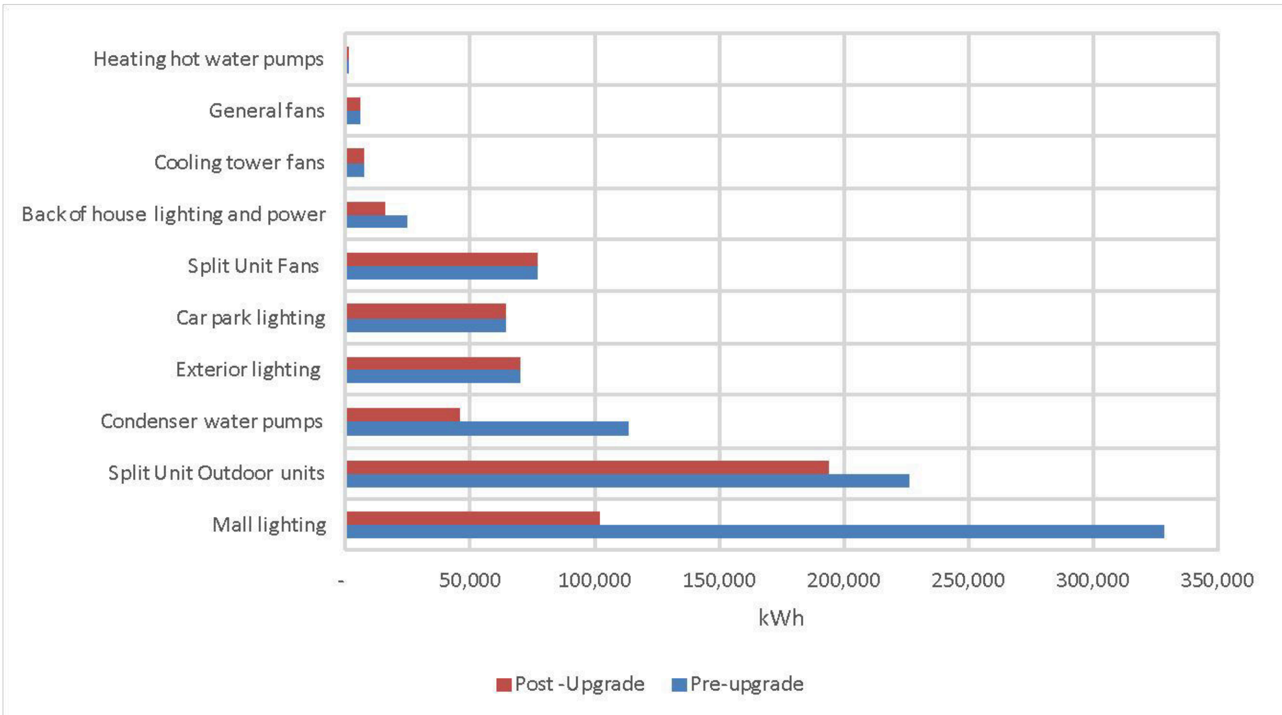

Figure 1. Pre-upgrade and post-upgrade electricity use breakdown

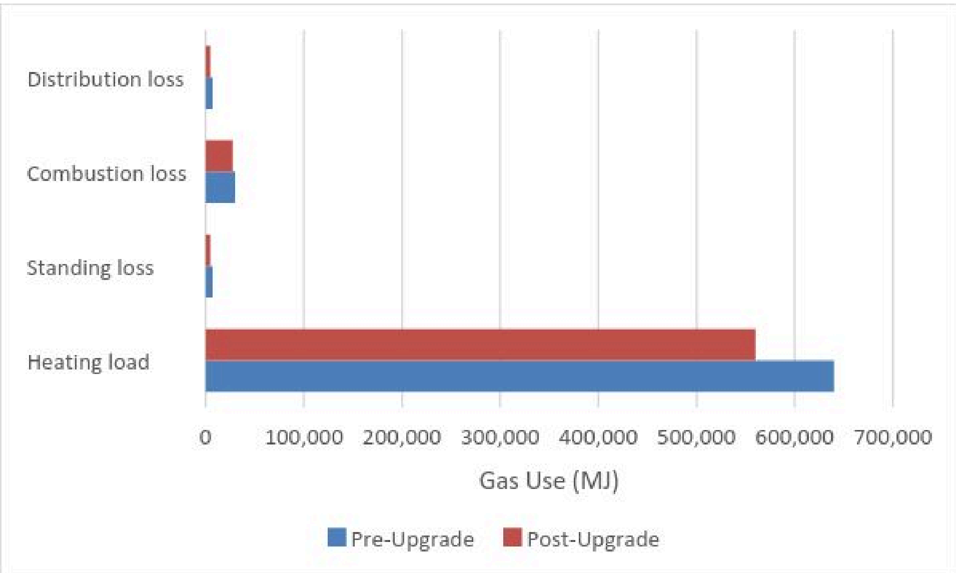

Figure 2. Pre-upgrade and post-upgrade gas end-use breakdown

1 Introduction

Project Background

This report details a Type 2 energy audit for Aotearoa Park Shopping Centre located at the corner of First and Second Streets in Motutapu, Auckland. This shopping centre is owned by Aotearoa Park Ltd. It is a single storey shopping centre with a tenancy area of 17,978.9 m^2.

Aotearoa Park Ltd's aspiration to become a leading sustainable company is reflected in their efforts to measure and report their buildings' performance. The overriding objective of this audit was to improve the site's energy performance as a means of substantially improving the site's environmental footprint as well to help attract and retain higher profile tenants.

This audit was carried out in accordance with the Type 2 requirements of AS/NZS 3598.1:2014 (referred to as the Standard elsewhere in this report).

The aims of this audit are as follows:

- Conduct an analysis of the base building energy consumption and develop a breakdown of the consumption.
- Identify energy efficiency upgrade measures with estimated costs and benefits.

Tariffs and costs were correct at the time of the audit, but changes may occur before the time of implementation. This would affect the forecasted financial savings and simple payback periods.

All dollar figures quoted in this report are exclusive of GST.

Scope of works undertaken

The scope of works is based on the findings of a one and half day site visit and subsequent analysis of consumption data and site documentation. The site visit was conducted by Alan Bloggs and Bill Jones on 26th June and 1st of July 2014. The site visit included the following key tasks:

- Site staff and contractors were interviewed to determine basic parameters of the facility's operation, characterise occupancy and scheduling patterns, and these were cross-checked against scheduling on the BMS

- Technical documentation including the key electrical and mechanical drawings were copied and/or photographed for our reference

- An inventory of base building energy using equipment was developed, including a lighting count and inspection of the mechanical services

- Electricity sub-meter readings were recorded to help to profile energy consumption patterns of the base building and tenants

- The on-site reticulation of electricity was investigated. Utility meters for gas and electricity were observed

The scope of the audit was limited to the base building only, covering:

- Car parks

- Services (lighting, HVAC) to common areas

- Condenser water loop

Lighting and power within tenancies were not included within the scope of this audit. Tenant air-conditioning units were connected to the associated tenant meter and thus were also not part of the scope of this audit.

2 Shorter Payback Recommendations (<5 year payback)

Common area zone temperature control

2.1.1 Background

The air-conditioning in the common area in the shopping centre is provided by six air-cooled package units and one water-cooled packaged unit. These units were all installed recently. The temperature set-points for all these units were uniform at 22 ºC. There appeared to be no dead band implemented on the packaged units for temperature control. During the site visit, mall unit 2 was observed to be cycling from cooling to heating - ie. The supply air temperature for this unit ranged from 7 ºC to 40 ºC within half an hour while the zone temperature ranged between 22 ºC to 24 ºC.

Dead-bands should be implemented on the common area units to eliminate this conflict and help avoid any conflict with the tenant air conditioning units.

2.1.2 Scope

- Set the dead band for common area air-conditioning units to be a total of 3ºC and control the compressors in the following stages:
  - Stage 1 cooling operates when zone temperature is 2 ºC above the set point and comes off at 1.5ºC above the set point;
  - Stage 2 cooling operates when zone temperature is 2.5 ºC above the set point and comes off at 2 ºC above the set point;
  - Stage 1 heating operates when zone temperature is 2 ºC below the set point and comes off at 1.5 ºC below the set point;
  - Stage 2 heating operates when zone temperature is 2.5 ºC below the set point and comes off at 2 ºC below the set point;

2.1.3 Savings calculations description

Simulation estimates for other building types indicate that changes in deadband of this magnitude can produce HVAC savings in excess of 20%. We have elected to conservatise this to 10% of the HVAC energy use identified in the end-use breakdown. This is a medium accuracy estimate in terms of the Standard.

Capital cost is based on an estimate of hourly rates, to be conducted within the existing contracting arrangements with the BMS provider. No project management or other costs have been added as this work is routine.

Measure	Common area zone temperature control
Annual energy consumption saving	33,000 kWh
Annual demand cost saving	N.A.
Annual energy cost saving	$ 3,000
Capital cost	$ 1,100
Pay back	0.4 Years

Primary condensing water loop control

2.1.4 Background

The condensing water loop consists of two primary pumps, two secondary pumps, a cooling tower and two auxiliary boilers. The primary condensing water pumps are equipped with VSDs. The condenser water loop only serves air-conditioning loads.

According to the BMS, primary pump 1 operates when the return condensing water temperature in the secondary loop exceeds 25 ºC. The primary pump and cooling tower fan operates in sequence when the secondary return condensing water temperature exceeds 26 ºC and 26.5 ºC respectively. This algorithm should be rectified to control to maintain the condensing water leaving temperature set-point on the secondary loop.

There are two condensing boilers connecting to the secondary condensing water loop, providing heat to the loop for the reverse cycle operation in winter. The boilers are in duty standby configuration each with its own heating water pump. Based on the BMS description, the boilers are switched on when the return secondary condensing water temperature is at or below 19 ºC. The boilers should be controlled to maintain the leaving water temperature instead of the return water temperature. The gas bills for the boiler gas meter showed about 20,000 MJ per month base load even during the summer months. This suggests the controls are not operating as described and the boilers were running during the summer, since there is no other apparent base building gas load on site.

2.1.5 Scope

- Operate the CW equipment during shopping centre open hours allowing 1 hour for start up in the morning
- Install VSD on the cooling tower fan.

- The condensing water leaving temperature in the secondary loop should be between 24ºC and 29.5 ºC (adjustable based on the package units design).
- Control the primary pumps and cooling fan speed using a PI loop to maintain the maximum condensing water leaving temperature at 29.5 ºC in the secondary loop in the following stages:
    - Stage 1- operate primary pump 1 at minimum speed (30% recommended) ;
    - Stage 2 - operate primary pump 2 at minimum speed (30% recommended) ;
    - Stage 3 - operate the cooling tower fan at minimum speed in stage 3;
    - Stage 4 - ramp up the cooling tower fan speed in stage 4 from minimum to maximum speed
    - Stage 5 - ramp up primary pump 1 and 2 in parallel;
- Control the lead and lag boilers using a PI loop to maintain the minimum condenser water leaving temperature no lower than 20ºC in the secondary loop in the following stages:
    - Stage 1 lead boiler to stage on at 21°C
    - Stage 2 lag boiler to stage on at minimum output when condensing water temperature is at 20ºC.
    - Stage down the lag boiler when condensing water temperature is at 22ºC and stage down the lead boiler when the temperature is at 21ºC
- Implement an 18°C outside air temperature lockout on the boilers and HHW pumps

2.1.6 Savings calculations description

This measure is primarily intended to improve control of the condenser water loop temperature and has a relatively minor energy saving component. The savings are calculated based on a percentage reduction of currently assessed energy use, and as such are a broad estimate as per the Standard.

Capital costs have been built up based on estimates of component costs. No allowance has been included for builder's works, as none will be required, and project management has been assumed to be in-house.

Measure	Primary condensing water loop control
Annual energy consumption saving	7,600 kWh 93 GJ gas
Annual demand cost saving	N.A.
Annual energy cost saving	$ 2,000

Capital cost	$ 5,800
Pay back	2.9 Years

Mall common area lighting upgrade

2.1.7 Background

The general mall common areas are illuminated by 150 W metal halide down lights and 50W halogen downlights. The lighting levels measured at the time of the site visit ranged from 220 lux to 340 lux. The recommended lighting level in the space is 160 lux according to AS1680. We recommend that the metal halide down lights are replaced by smaller output lamps.

The halogen lighting should be replaced with quality high output LED downlights.

2.1.8 Scope

- Replace the 150 W metal halide down lights with 70 W metal halide down lights
- Replace the 50W halogen downlights with quality high output LED downlights

2.1.9 Savings calculations description

The energy saving is calculated based on the reduction in unit power draw and the identified hours of operation. This is a medium accuracy estimate as per the Standard.

Note that we have priced this based on manufacturers' quotes using a one-for-one replacement approach. We have allowed for labour rates and platform hire associated with installation, but as this is routine work, no additional project management fees have been included. We have not allowed for design costs, as this should not be necessary for a 1:1 replacement. We have furthermore assumed that no builder's works such as patching or repainting are involved.

Measure	Mall common area lighting upgrade
Annual energy consumption saving	130,000 kWh
Annual demand cost saving	$1,500.
Annual energy cost saving (including demand saving)	$ 12,000
Capital cost	$ 50,000
Pay back	4.2 Years

Skylight pelmet lighting control

2.1.10 Background

Some of the common area in the mall is illuminated with a mixture of artificial lighting and daylight through skylight. Linear fluorescent 58W T8 lamps are installed in pelmets around the skylights. The pelmet lighting was observed to be on even when the ambient lighting level is sufficient. It is recommended to upgrade these fluorescent lamps to LED. Daylight control and time control for this pelmet lighting is also recommended.

2.1.11 Scope

- Replace the 58W T8 pelmet lighting with LED retrofit lamp.
- Install one PE cell under each skylight. The PE cell should be positioned in areas that receive the least amount of daylight and should be positioned out of area that would receive direct sunlight at any time of the day.
- Measure the lux level at the least lit area. When it is 160 lux, measure the corresponding lux level at the PE cell. This defines the set-point for the PE cell.
- The pelmet lighting should be programmed to be activated during the mall trading hours. When the PE cell reaches its set-point, the pelmet should be switched off.

2.1.12 Savings calculations

- The calculation assumes a 20% operation time reduction during the day as well as a reduction in lighting power draw based on the wattage difference. This is a medium accuracy estimate as per the Standard.
- The cost is estimated by manufacturers' quotes plus installation costs. No design costs, builder's works or project management costs have been allowed for as these are not expected to be necessary.

Measure	Skylight pelmet lighting control
Annual energy consumption saving	33,000 kWh
Annual demand cost saving	$ 300
Annual energy cost saving (including demand saving)	$ 3,000
Capital cost	$14,000
Pay back	4.7 Years

3 Longer Payback Measures (>5 years payback)

Exterior mercury vapour pendant lighting replacement

3.1.1 Background

There are a number of mercury vapour pendant lights near the entrance of the shopping mall. These luminaires are old and deteriorated and need to be upgraded. The efficacy of mercury vapour lights is also very poor. Quality LED replacements for these luminaires are recommended.

3.1.2 Scope

- Replace the pedant mercury vapour lights with 160 W LED high bays.

3.1.3 Savings calculation description

- The savings calculation is based on the reduction of the power draw –62%. This is a medium accuracy estimate as per the Standard.
- The cost is estimated based on the manufacturer's quote and plus installation. No design costs, builder's works or project management costs have been allowed for as these are not expected to be necessary.
- We have allowed for a one for one replacement of the existing units

Measure	Exterior mercury vapour pendant lightings replacement
Annual energy consumption saving	21,000 kWh
Annual demand cost saving	$ 200
Annual energy cost saving (including demand saving)	$ 1,900
Capital cost	$12,000
Pay back	6.3 Years

Re-circuit security lighting for the mall

3.1.4 Background

The mall lighting is scheduled on from 5 am in the morning till 3 am in the morning the next day, or 22 hours per day. There is currently no after hours minimum lighting circuit in place. The lighting levels in the mall have been measured at approximately 220-340 lux; by comparison, the recommended security lighting level is 80 lux. If a security lighting circuit can be provided, the operation time of the majority of the mall lighting can be significantly reduced.

3.1.5 Scope

- Re-circuit security lighting for the mall so that every third light can be used as a security light, and the rest switched off after hours.

3.1.6 Savings calculation description

- The savings calculation assumed a third of lights operating 24 hours per day. The other mall lights only operate during the mall shopping hours. The estimated saving is approximately 33% of current operation. This is a medium accuracy calculation as per the Standard

- The cost of this measure has been provided by the electrical contractor. No design costs, builder's works or project management costs have been allowed for as these are not expected to be necessary.

Measure	Re-circuit security lighting for the mall
Annual energy consumption saving	51,000 kWh
Annual demand cost saving	N.A.
Annual energy cost saving	$ 3,500
Capital cost	$30,000
Pay back	8.6 Years

Back of house lighting upgrade

3.1.7 Background

The back of house area is illuminated by 2×36W T8 fluorescent fittings. The lighting levels in these areas are around 200 lux. The BMS shows that these lights are only off during 3 am to 4 am each day. LED replacements for these luminaires together with occupancy controls are recommended.

3.1.8 Scope

- Replace the 2×36 W T8 with 35 W standard Chamaeleon LED or similar.

3.1.9 Savings calculation description

- The calculation assumed the back of house lights will only be on during mall hours after upgrade.
- The savings are based on the reduction of the power draw of 60% and a reduction in the operating time of these luminaires of 48%. This is a medium accuracy estimate as per the Standard.
- The cost is estimated based on average internal supply and install pricing for the luminaire. No design costs, builder's works or project management costs have been allowed for as these are not expected to be necessary.

Measure	Back of house lighting upgrade
Annual energy consumption saving	4,700 kWh
Annual demand cost saving	$ 30
Annual energy cost saving	$ 370
Capital cost	$3,700
Pay back	9.3 Years

Secondary condensing water loop pressure control

3.1.10 Background

The air conditioning services in this shopping centre are provided by water-cooled and air-cooled package units. Approximately two thirds of the tenancies are served by water-cooled packaged units (approximately 40 units). Site management have confirmed that there is only one water-cooled packaged unit for the mall area. The shopping centre has a condenser water loop for heat rejection for both the mall and the tenancy water-cooled package units in a primary-secondary loop configuration. The secondary loop is also supplemented by condensing boilers for heat input in winter.

During the site visit, the two secondary condensing water pumps were observed to operate at 100% speed when some of the water-cooled units (WCUs) were not running. Note that the site advised that the loop has minimal spare capacity.

3.1.11 Scope

- Install automatic shut-off valves or head pressure reduction valves on all the water-cooled package units – shut-off valves to be interlocked with the compressor operation. Head pressure reduction valves must shut to mil flow when the compressor is not running.
- Install a differential pressure sensor on the secondary condensing water loop, close to the index run, and commission a set-point to be the pressure drop required to provide flow to the index run and/or WCU in the loop. Connect the pressure sensor output to the BMS.
- Connect the shut-off valve and/or compressor status to the BMS for the units currently on the BMS.
- Stage the secondary condensing water pumps in the following sequence to maintain the differential pressure set-point:
    - Run the secondary pump 1 in minimum speed;
    - Run the secondary pump 1 and pump 2 together in minimum speed;
    - Ramp up the pump speed in parallel to maintain the pressure differential sensor set-point;

3.1.12 Comments

It is understood from discussions with site management that access to many of the water cooled package units may be restricted. Accordingly, we recommend that the work is broken into multiple stages, firstly to upgrade the base building and tenant WCUs with sufficient access, then secondly to upgrade the balance of WCUs over time as the WCUs are replaced at end of life.

We have provided a breakdown of savings below to inform the planning process, on the basis of a nominal 10% of units having sufficient access. We have discussed upgrade of the tenant air conditioning units in Section 3.7.

3.1.13 Savings calculations description

- The flow turndown rate is estimated at 40% based on the number of water-cooled package units in operation during the site visit. 50% of this turndown is assumed to be achieved during the shoulder season and 20% turndown has been assumed for the summer months.

- A square turndown relationship between the flow and the energy is assumed to calculate the savings. This is a medium accuracy estimate as per the Standard.

- The costs have been built up on the basis of a $2,500 per valve installation cost plus additional costs for installation of a differential pressure sensor, programming and commission, based on experience from other projects. No project management costs have been allowed for as it is expected that this will be project managed in-house.

Measure	Secondary condensing water loop pressure control		
	WCUs to be upgrade – assumed nominal 10% of units	Balance of upgrade – end of life replacement	Total
Annual energy consumption saving	6,000 kWh	55,000 kWh	61,000 kWh
Annual demand cost saving	$100	$1,100	$1,200
Annual energy cost saving (including demand saving)	$ 700	$ 6,100	$ 6,800
Capital cost	$ 12,000	$ 108,000	$ 120,000
Pay back	18 Years	18 Years	18 Years

Toilet lighting occupancy control

3.1.14 Background

There are two groups of toilets in the shopping mall, located in the south mall and north mall respectively. The toilet lighting has been recently upgraded using 10 W LED downlights on occupancy control. However, there is only one occupancy sensor at the entrance of each toilet and there is no sensor in the space. The operating time of the luminaires is likely to be set to a long period to overcome the limitations of this sensing configuration. Installing another occupancy sensor in the space would make a shorter operating time possible.

3.1.15 Scope

- Install another ultrasonic occupancy sensor in each bathroom and set the operating time to be 15 min when detecting no occupancy.

3.1.16 Savings calculation description

- The calculation assumed 15% energy use reduction for the toilets lighting after the upgrade. It is noted that this measure is largely intended to provide better control and eliminate the chance of a customer being caught in the dark. This is a medium accuracy estimate as per the Standard.
- The cost is based on the electrical contractor's estimate. No design costs, builder's works or project management costs have been allowed for as these are not expected to be necessary.

Measure	Toilet lighting occupancy control
Annual energy consumption saving	1,000 kWh
Annual demand cost saving	N.A.
Annual energy cost saving	$ 100
Capital cost	$4,800
Pay back	48 Years

Tenant package units life cycle replacement

3.1.17 Background

The air-conditioning in the tenancy area is provided by air-cooled or water-cooled package units. There are sixty-five units, covering all the tenancies except for majors which have their own air conditioning systems. These air-conditioners are on the tenant meters and not the base building meters and are technically out of the scope of this audit. Out of the sixty-five units, ten have been recently upgraded while the rest of the units are around twenty years old and generally in very poor condition.

The air-cooled package units also typically do not have economy cycles and are not connected to the BMS. Our observations on site indicate that tenant package unit set-points, which ranged from 21.5ºC to 24ºC, are likely to be causing conflicting operation with the mall common area units.

There is a clear need for the older units to be upgraded to modern high efficiency alternatives. As there is no separate metering of the tenant air conditioning units, we have provided only order of magnitude energy savings for this measure. These savings will have no impact on the base building performance and are intended to capture broader sustainability objects for the shopping centre.

We have tailored the scope of this measure as a like-for-like replacement, however we also recommend consideration be given to one of several best-practice upgrade solutions as discussed below.

3.1.18 Scope

- Upgrade tenant air-cooled split units to high performance (design COP of greater than 3) modern inverter units

- Upgrade air cooled packaged units to modern high performance variable compressor and fan air cooled packaged units with full economy cycle – such as the Temperzone OPA model.

- Upgrade water cooled packaged units to modern high performance water cooled systems.

- Connect units to tenant package units control signals to the centre management BMS.

- Set the zone temperature set-point for the tenant package units to be 22.5 ºC and set the dead band of these units to be 1 ºC. The units should be staging as following depending on the number of compressors.

    - Stage 1 cooling comes on at 1.5 ºC above the set-point and comes off at 1.0 ºC above the set point.

    - Stage 2 cooling comes on at 2.0 ºC above the set-point and comes off at 1.5 ºC above the set point.

    - Stage 1 heating comes on at 1.5 ºC below the set-point and comes off at 1.0 ºC below the set point.

    - Stage 2 heating comes on at 2.0 ºC below the set-point and comes off at 1.5 ºC below the set point.

- The economy cycle of the package units should be controlled as follows:

    - The economy cycle should only be enabled when:

        - the outside air temperature is less than 23°C dry bulb, AND

        - the outside air temperature is less than the return air temperature, AND

        - the dew point of outside air is less than 15 ºC

    - The economy cycle should be programmed as the first stage of cooling. The outside air damper should be modulated from minimum to 100% when the zone temperature deviation is from 0 to 0.5 ºC above the deadband.

3.1.19 Comments

Consideration should be given to the following issues and solutions in order to achieve a best practice outcome:

1. A significant proportion of the tenancies are served by individual air cooled split units. Many of these have reached or passed their design life and are due for replacement. Having a high number of individual split units results in higher maintenance costs. Higher performance and lower maintenance costs could be achieved through installation of multi-head VRV systems serving clusters of tenancies.

2. For larger tenancies that are currently served by either water-cooled or air cooled systems without economy cycle and that are due to undergo fitout, consideration should be given to installing full outside air ductwork and installing full economy cycle packaged units.

3.1.20 Savings calculation description

This measure has no direct impact on the energy consumption within the scope of this audit but it will result in improved performance of tenant air conditioning with consequent greenhouse gas reduction on a more holistic basis. Note that there will be marginal base building NABERS improvements from this measure arising from the decreased load and compressor operating times on the tenant condenser water loop and the reduction in heating and cooling conflicts between tenancy and common area air-conditioning systems. The control strategies also have flow-on benefits to tenant comfort conditions. A preliminary calculation suggests that a total of 500,000 kWh can be saved from the tenancy air-conditioning consumption. This is a broad estimate as per the Standard..

4 Energy Management Measures

Energy Management Program Enhancements

4.1.1 Background

The site has an aggressive energy efficiency target of a 25% reduction in energy use relative to 2010 by 2016, although to date consumption has only reduced by 5%. This audit has identified that the 25% reduction is quite achievable, but not within the 3 year payback criterion normally applied; this to some extent has already been recognised given the request to seek measures less than 5 year payback in this audit. However, the nature of the site and available measures is such that achievement of the target will require changes to on-site energy management and investment practices.

4.1.2 Scope

- Monthly reporting should be expanded to include, as a minimum:
  - A review of daily energy use profile
  - Comparison of site energy use against the benchmarks established in Section 5.
- Site documentation. Processes should be put in place to ensure that tenancy refurbishments are fully documented, particularly when they affect the air-conditioning design or operation. An electronic archive should be established with scans of existing plans plus as-built documentation for refurbishments
- Consideration should be given to providing additional training to the Site Manager in the area of basic air-conditioning technology and energy monitoring.
- The criteria for energy efficiency investment need to be reviewed as the current 3 year payback threshold is not compatible with the range of investments that is required to achieve the desired energy efficiency target. As many of the required investments are of a deferred capital or deferred maintenance nature, we recommend that a more strategic approach is adopted, considering service life, services levels and commercial risk as well as pure energy payback.
- Measures should be put in place to improve, over time, the accessibility of tenant air-conditioners to ensure that these can be properly maintained. This should occur in parallel with the end-of-life replacement of these units.

- Procurement policies. The site has no particular procurement policies in relation to energy efficiency. Consideration should be given to adopting enhanced procurement standards including:
    - Minimum COP of 3 for package unit air-conditioners
    - Inverter compressors for all air-cooled package unit air-conditioners
    - Economy cycle for all air-conditioners above 30kWth
    - No new halogen, mercury vapour or compact fluorescent light sources

4.1.3 Savings calculation description

No direct savings can be imputed against this measure, but it will facilitate implementation of the savings identified in this report.

Energy sub-meter installation

4.1.4 Background

There is only one utility meter for the whole site, supplying electricity to both the shopping centre common area and the tenants. Installation of electricity sub-meters will enable monitoring of the energy use of the site and help to identify further energy efficiency opportunities. This will help in maintaining the site energy performance into the future, and provide baseline data for analysing the impact of energy efficiency upgrade.

4.1.5 Scope

Electricity sub-meters installation

- Install a total of 7 electricity sub-meters as per Table 2 below:

<table>
<tr><td rowspan="5">Utility meter
NMI VBBB0002846</td><td>Tenant supplies</td><td colspan="2">No further metering</td></tr>
<tr><td rowspan="4">Meter 1
Shopping centre common area supplies</td><td rowspan="2">Virtual Meter 1
HVAC</td><td>Meter 2
PAC units
Board MSSB-R1</td></tr>
<tr><td>Meter 3
Condensing water plant
Board MSSB-1</td></tr>
<tr><td>Meter 8</td><td>Meter 4</td></tr>
</table>

		Board PLDB-1	Lighting Board PLDB-1
			Meter 5 Power Board PLDB-1
		Meter 9 Board PLDB-2	*Meter 6* Lighting Board PLDB-2
			Meter 7 Power Board PLDB-2

Table 2 Electricity sub-metering plan

4.1.6 Savings calculations description

- The savings have not been estimated in this measure since it is not a direct energy and water saving measure.
- The cost has been developed based on the site metering contractor's quote, with a 10% contingency. No allowance has been made for other costs as no builder's work or further design is expected to be required, and it has been assumed that the site will project manage installation.
- The allowance for water sub-meters is made based on the meter price for 50mm pipes

Measure	Energy sub-meter installation
Annual energy consumption saving	N.A.
Annual water consumption saving	N.A.
Annual demand saving	N.A
Annual energy cost saving	N.A.
Annual water cost saving	N.A.
Capital cost	$82,000
Pay back	N.A.

5 Appendix 1: Energy consumption characteristics

Electricity

5.1.1 Electricity account

There is one electricity supply for the shopping centre and it supplies both the house and tenant consumption. The tenant consumption has been passed onto the tenants via an embedded network. The details of the main account are presented in Table 3.

NMI	VBBB0002846
Supplier	AGL
Customer account number	1056 0373
Account holder	Lend lease
Meter number	213232373
Coverage	Whole site

Table 3 Electricity account information

5.1.2 Sub-meter consumption

The site uses an embedded network to measure tenant electricity consumption for on-charging. The site used a total of 3,290,819 kWh utility consumption during the audit period. Based on the sub-meter data provided, the total sub-metered consumption during the audit period was 3,270,796 kWh. The difference is less than 1%. The sub-metered base building consumption during the same period was 929,370 kWh. A more detailed reconciliation of utility and sub-meter consumption is shown in Table 4.

Note that the % difference between the utility and embedded network ranges from 1 to 12%.

Month	Total utility consumption (kWh)	Total sub-metered consumption(kWh)	% difference between utility and embedded network	Base building sub-metered consumption (kWh)	Tenant sub-metered consumption (kWh)
Jun-13	267,066	264,028	99%	86,743	177,285
July-13	276,802	271,469	98%	89,905	181,564
Aug-13	280,924	258,552	92%	86,142	172,410
Sep-13	260,465	255,776	98%	74,559	181,217

Oct-13	265,184	246,178	93%	65,606	180,572
Nov-13	249,393	280,183	112%	60,405	219,778
Dec-13	295,273	286,180	97%	83,925	202,255
Jan-14	308,814	335,833	109%	84,155	251,678
Feb-14	274,558	257,009	94%	75,076	181,933
Mar-14	284,461	298,127	105%	76,386	221,741
Apr-14	258,093	251,014	97%	72,249	178,765
May-14	269,785	266,448	99%	74,220	192,228
Total	**3,290,819**	**3,270,796**		**929,370**	**2,341,426**

Table 4 Electricity sub-metered consumption

5.1.3 Electricity tariff description

The detail of the billed information is taken from the bill for 2014 May and is presented in Table 5..

Item	**Rate/Unit**
Energy charges	
Weekday 0000-0800, 2000-2400	\$0.055/kWh
Weekday 0800-2000	\$0.087/kWh
Weekend 0000-0800, 2000-2400	\$0.055/kWh
Weekend 0800-2000	\$0.065/kWh
Network charges	
Network supply charge	\$0.025/kWh
Network variable demand charge	\$7.41/kVA/month
Fixed charge	\$85.16/month

Table 5 Electricity billing information

5.1.4 Electricity time of use profile

The monthly consumption chart is presented in Figure 2. The average profiles for different seasons and weekdays have also been developed using utility interval data. It is noted that the average profile is for the whole site including the base building and the tenants. The average profiles are presented in Figure 3 and Figure 4.

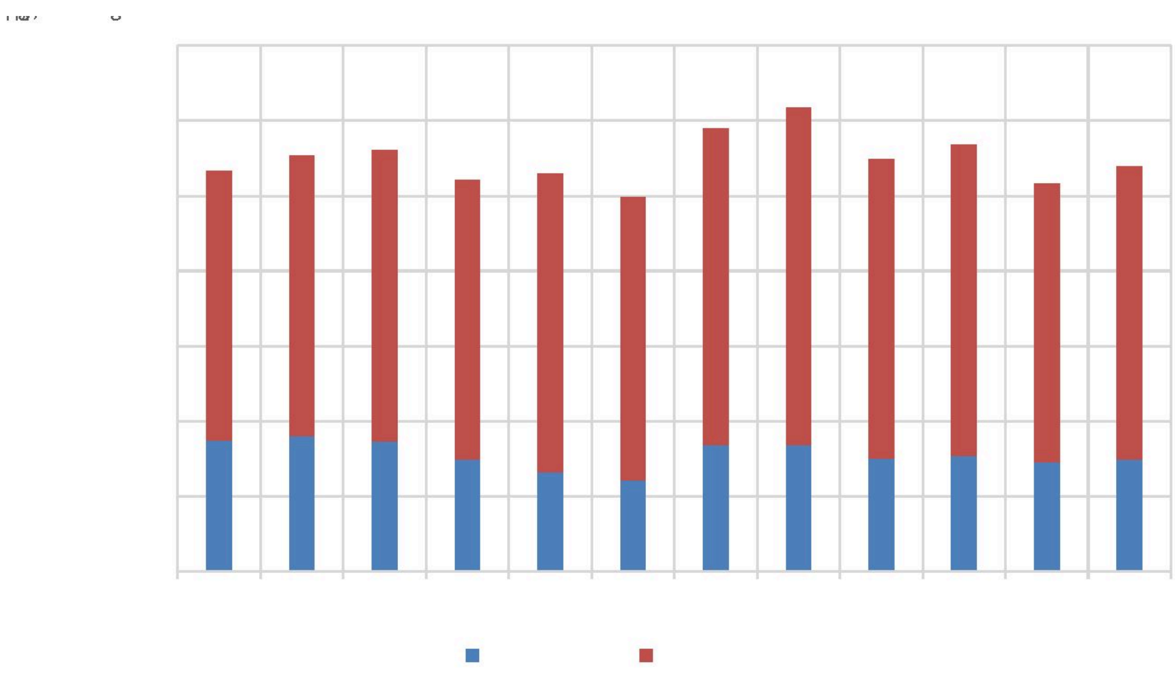

Figure 3 Electricity monthly use

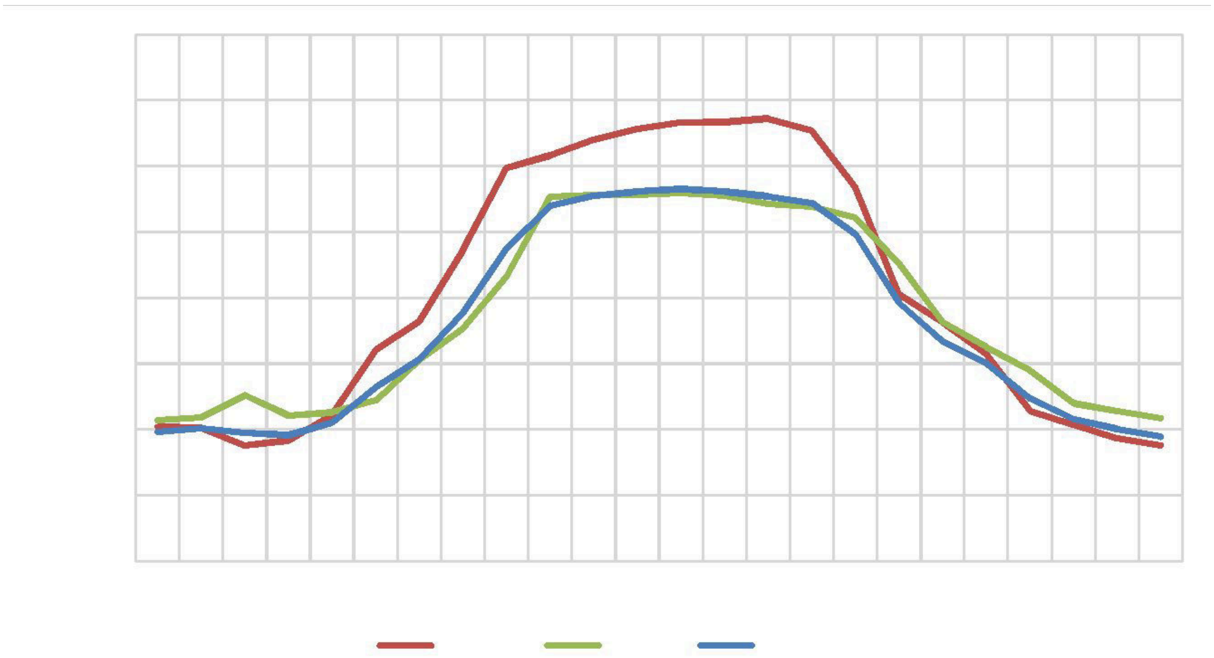

Figure 4 Average seasonal whole building profiles

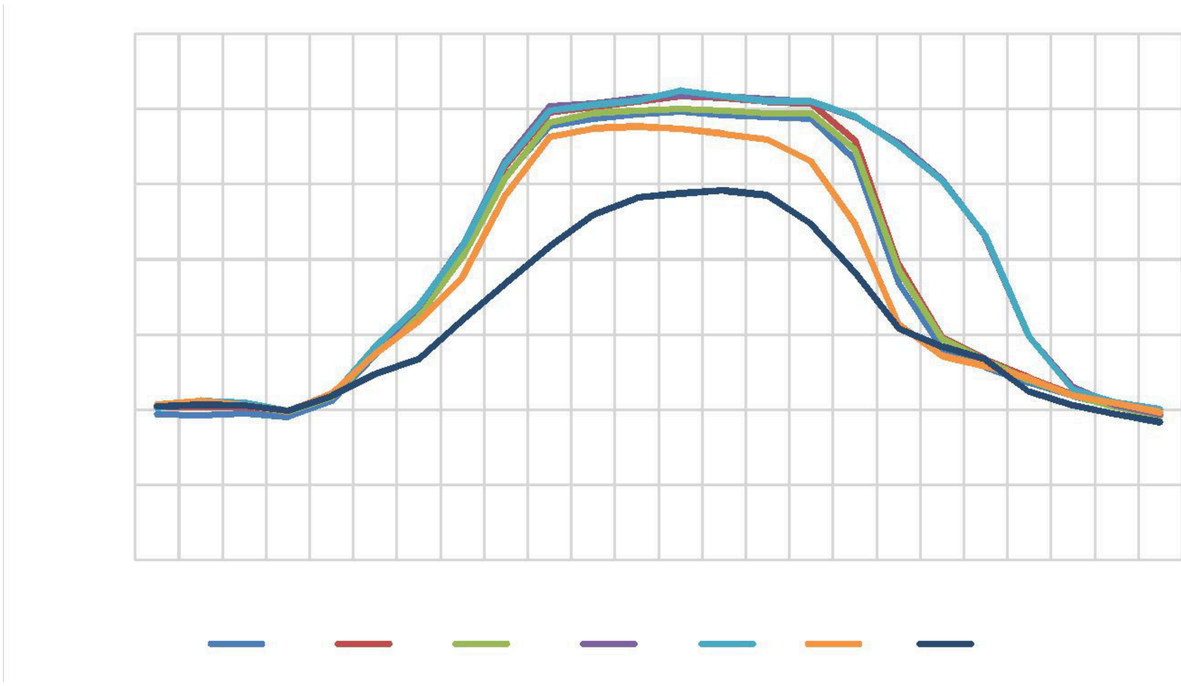

Figure 5 Weekdays average whole building profiles

Key points to draw from these profiles are:

- Seasonality was evident for the shopping centre. The peak load in summer was approximately 680 kW and the peak load for other seasons ranged from 520-600 kW. The seasonal variations are consistent for both the base building and the tenants.
- The average base load for the building was approximately 200 kW. The base load in winter was slightly higher than other seasons.
- Profiles for Thursday and Friday exhibit extended trading hours and are similar to each other. The Saturday and Sunday profiles are different from all other weekday profiles.
- Note the breakdown of base building consumption between opening and overnight hours per month is provided in Figure 5 below.

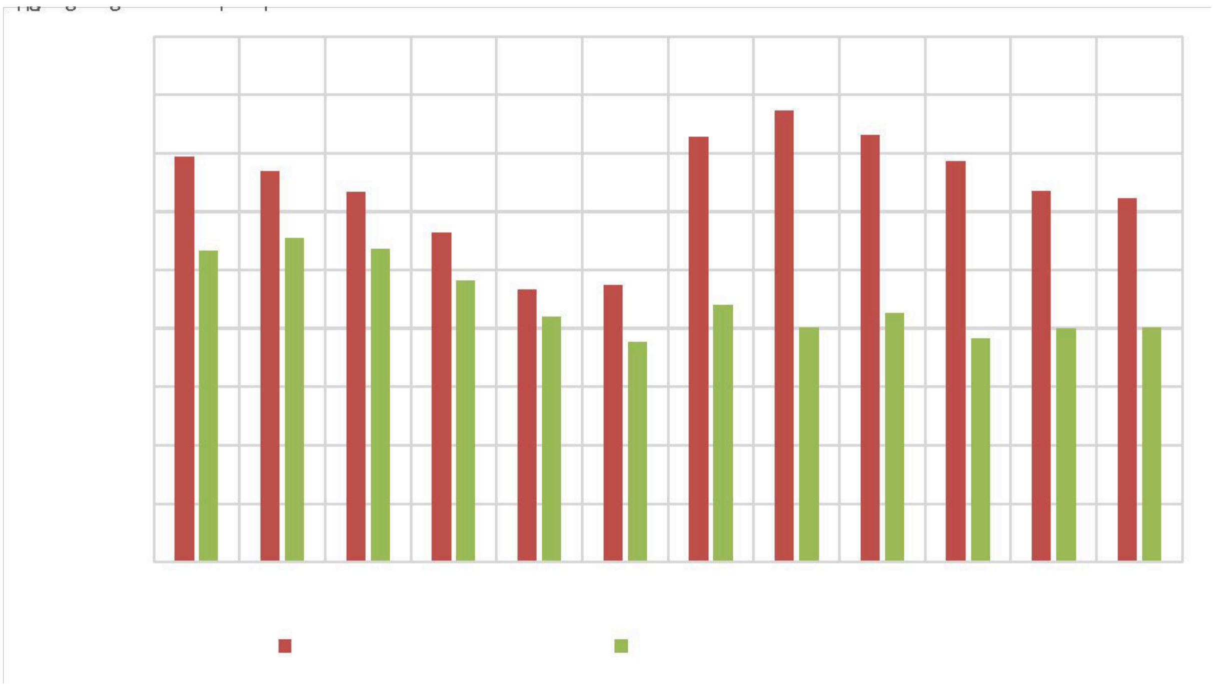

Figure 6 Base building trading hours and non-trading hours average consumption

For this audit, the embedded network operator provided the tenant and base building energy consumption data in peak and off-peak consumption categories but no time interval data. As a result, we have developed the end-use analysis based on known information, including the breakdown in the whole of site interval data, tenant total peak and offpeak consumption, estimated peak HVAC and lighting equipment loads and seasonal variance.

5.1.5 Comparison with available benchmarks

The nature of shopping centre base building energy use, for which the coverage varies significantly from site to site, means that there are no readily available comparison indicators for energy intensity. As the nearest alternative, we have estimated the site's performance using the Australian NABERS for Shopping Centres rating, obtaining a rating of 3 stars. This indicates – in so far as the application of the tool in New Zealand is sensible – that the site's energy performance is close to average.

1.1.1 Climate correlation

The amount of data available for the preparation of a climate-corrected benchmark for the base building was less than desirable owing to inadequate records of tenant energy use. However, based on the available data, the following climate-corrected benchmark for base building electricity use has been generated. The nature of the HVAC plant is such that both summer and winter peaks occur, so the correlation includes recognition of both heating (HDD) and cooling (CDD) drivers.

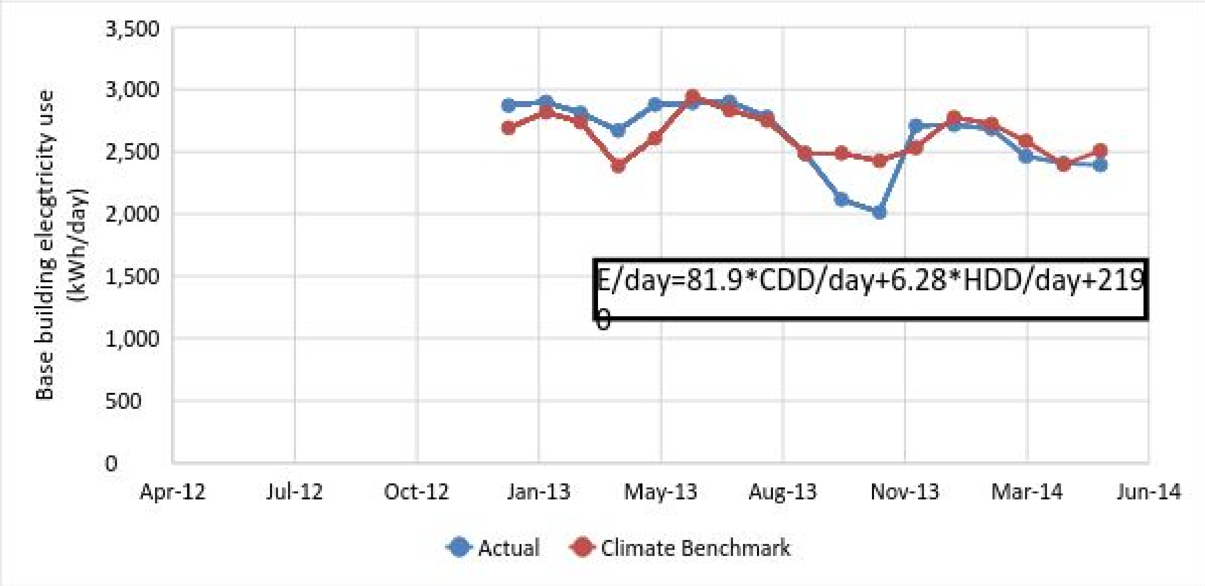

Figure 7. Climate corrected benchmark for base building electricity consumption.

The high level of variability between benchmark and actual indicates either the presence of other drivers for energy use or potential inefficiencies.

1.1.2 Electricity use breakdown

The electricity use breakdown was developed based analysis of the site's seasonal daily electricity profiles, off-peak and peak consumption, the observed equipment load and operational patterns.

The energy use breakdown table and the pie chart is shown below.

Category	Consumption (kWh)	Percentage
Mall lighting	330,000	36%
Pack Unit Compressors	230,000	25%
Condenser water pump	110,000	12%
Exterior lighting	70,000	8%
Car park lighting	64,000	7%
Pack Unit Fans (supply)	77,000	8%

Back of house lighting and power	25,000	3%
Cooling tower fan	7,400	1%
General Fans	5,400	<1%
Heating hot water pump	380	<1%
Total	920,000	100%

Table 6 Electricity use breakdown

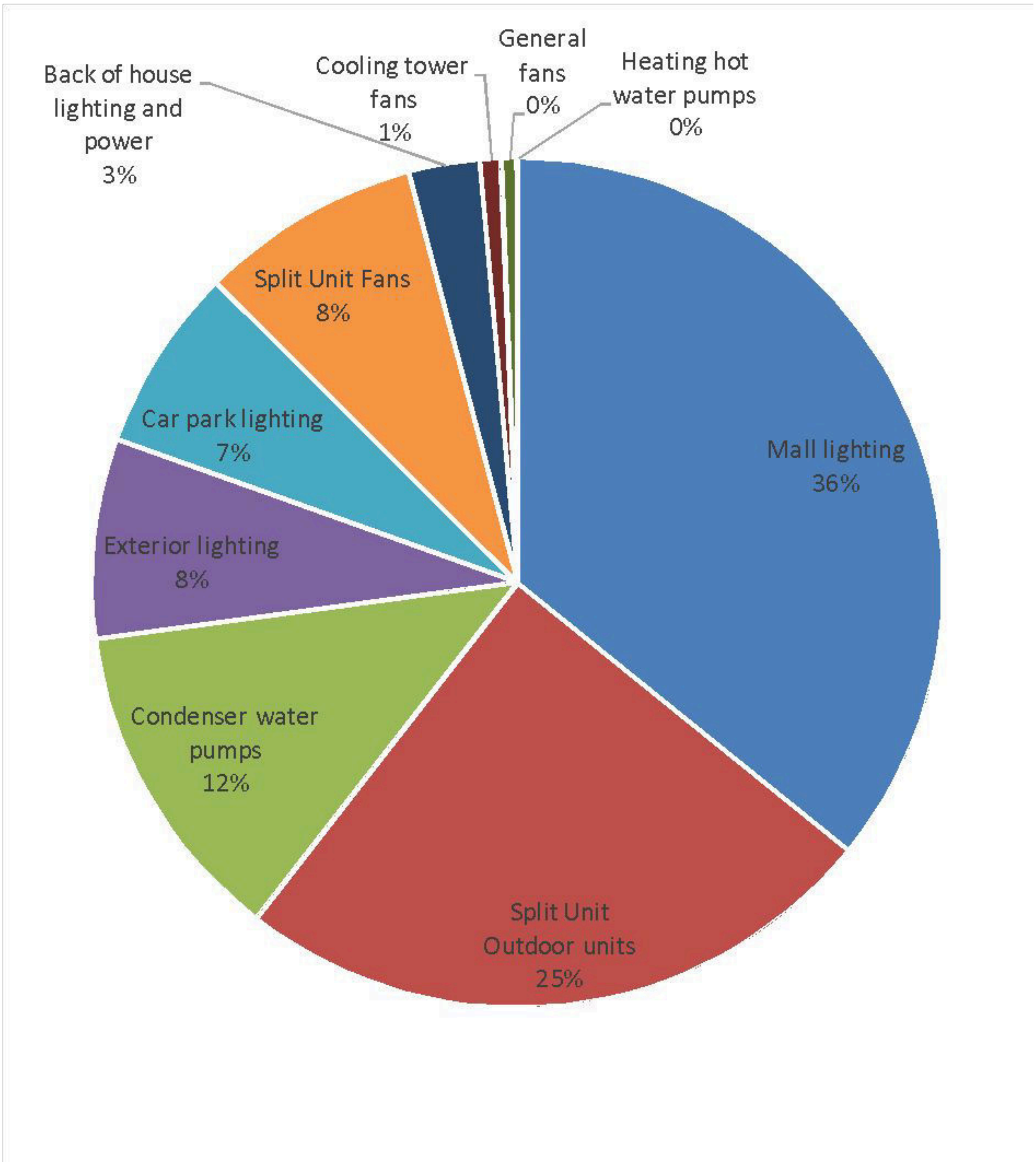

Figure 8 Electricity use breakdown

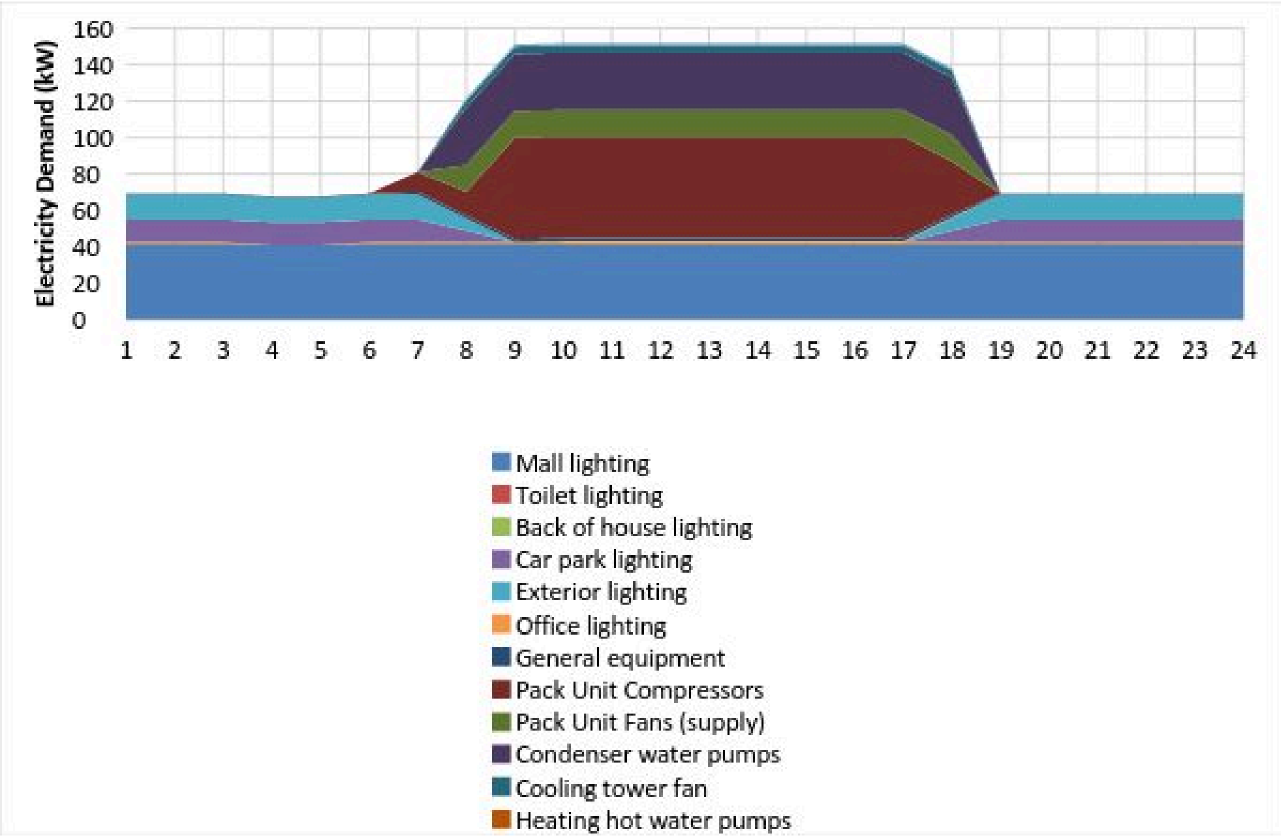

Figure 9. Time of use energy end-use breakdown. Owing to the relative stability of seasonal energy use, a single annual profile has been developed rather than separate seasonal profiles

Gas

5.1.6 Gas account

There is only one gas account for the base building, which is for the condensing boilers in the condensing water loop. The gas account detailed information is presented in Table 7

Retailer	AGL
Account number	7630 5275
Account holder	Lend Lease
MIRN	53102746537
Meter number	5120YR
Coverage	Base building

Table 7 Gas account information

5.1.7 Gas consumption

The consumption from the 1/03/2013 to 28/02/2014 was 692,363 MJ, which is the rated gas consumption for the audit period. The average cost for gas was approximately $0.014/MJ. Due to the billing period of gas, the normalized monthly gas consumption has been calculated and it is presented in Figure 10. The peak gas consumption occurred in Jun 2013 due to the boiler operation. However base load of about 20,000 MJ was evident from October 2013 to Feb 2014. It is noted that the boiler shouldn't be running during summer months. The presence of the base load might be due to the control issues.

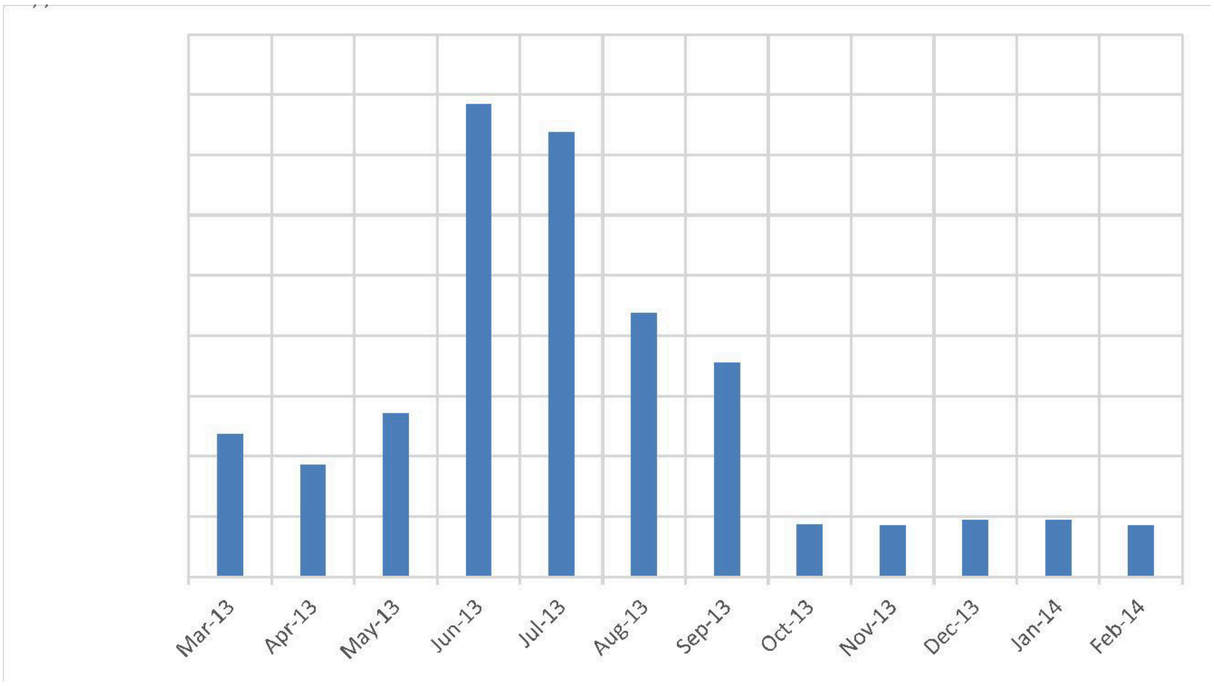

Figure 10 Normalized monthly gas consumption

5.1.8 Climate correlation

Only a limited period of data was available for gas, which has limited the duration of the baseline period for climate correlation. However, a strong correlation with heating has been identified as shown below.

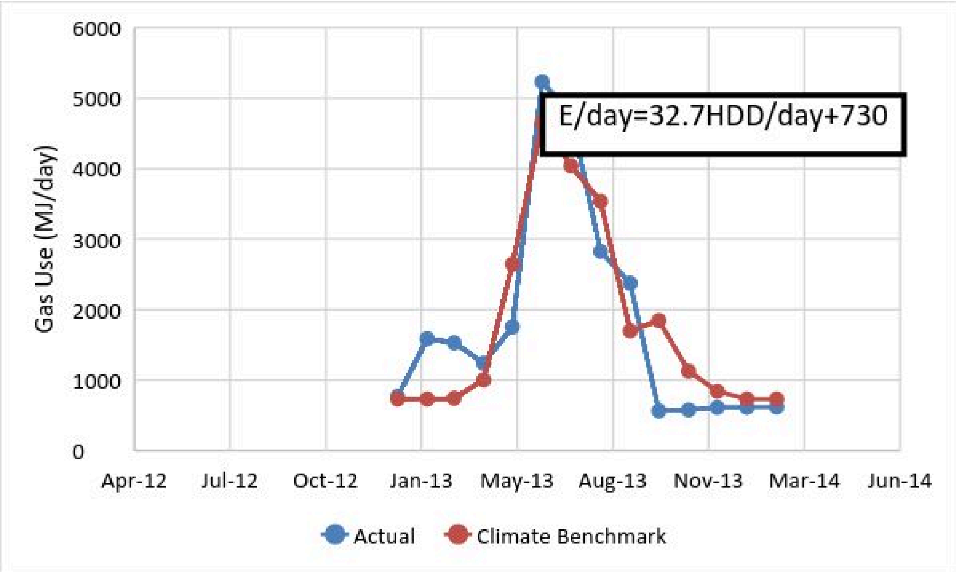

Figure 11. Climate corrected benchmark for site gas consumption.

The high level of variability between benchmark and actual indicates either the presence of other drivers for energy use or potential inefficiencies.

5.1.9 Gas use breakdown

The shopping centre has one gas account for the house consumption and several other accounts for the tenant consumption use. The detailed gas account information is presented in the Appendix section. The house gas use is for the condensing boilers as auxiliary heat source only. The gas use breakdown table and the pie chart is presented below

Components	Consumption (MJ)	Percentage %
Heating load	640,000	93%
Standing loss	7,000	1%
Combustion loss	30,000	5%

Distribution loss	7,000	1%
Total	690,000	100%

Table 8 Gas use breakdown

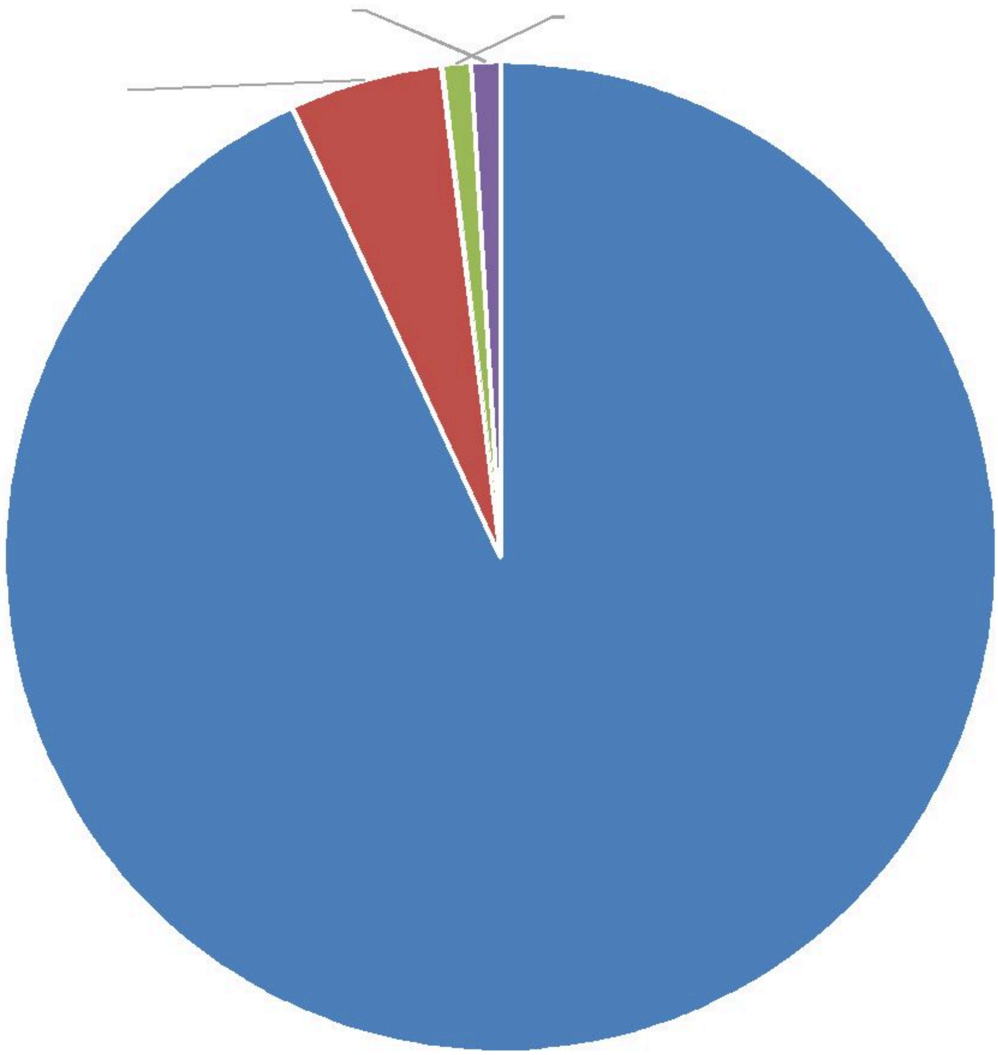

Figure 12 Gas use breakdown

6 Appendix 2: Site Description

Improvement history

Aotearoa Park Shopping Centre is a circa 1980 shopping centre which has had two recent major HVAC plant upgrades.

The most recent upgrade approximately 12 months ago included upgrade of the site condenser water system which serves tenant packaged units as well as a single base building packaged unit. The condenser water upgrade consisted of new condenser water pumps with VSDs and condensing boilers. The BMS was also upgraded as part of the works. Approximately 3 years prior to that, a number of air cooled ducted split units were installed to serve the common area.

HVAC system

The air-conditioning in the shopping centre is provided by a mix of water-cooled package units, air-cooled package units and air-cooled split units. The base building air-conditioning does not provide services, other than condenser water, to any of the tenants.

There is one centralised condenser water loop in a primary - secondary configuration providing heat rejection for both the base building and the tenant water-cooled package units. Two condensing boilers provide heat injection to the condenser water loop for winter operation. These operate in duty/standby configuration and are connected to the secondary side of the condensing water loop via plate heat exchangers. The following sections give more details of each sub-systems.

6.1.1 Package units and split units

There are 76 units in total for both base building and tenants. There are 7 units serving the mall common area and 1 unit serving the centre management office. The rest of the units serve the tenants. The majors have their own HVAC plant and there units are not included in this section. Some basic facts about these units are provided in Table 9.

The mall units and a few tenant package units have been recently upgraded. However, most of the other units are 15-20 years old, use R22 refrigerant and are reaching the end of their economic life.

The air-cooled package units are located on the rooftop and have minimum fresh air supply. These units do not have the full fresh air intake economy cycle capability.

Total number of units	76	Total estimated cooling capacity 2009 kWr
Base building units	8	1 Water-cooled PAC Estimated cooling capacity 45 kWr
		1 Air-cooled PAC Cooling capacity 14 kWr
		6 Split units Total estimated cooling capacity 270 kWr
Tenant units	68	39 Water-cooled PAC Total cooling capacity 1,200 kWr
		8 Air-cooled PAC Total estimated cooling capacity 240 kWr
		21 Split units Total estimated cooling capacity 240kWr

Table 9 All Package units information (Excluding majors)

6.1.2 Condensing water loop plant

There is a centralised condensing water loop plant providing heat rejection for all the water-cooled package units. This loop is in a primary/secondary configuration with a cooling tower on the primary side and additional condensing boilers as auxiliary heating sources connected to the secondary side. The schematic of this loop is shown in Figure 12. The specifications of these equipment in the loop are list in the tables below. The condensing water pumps are all equipped with VSDs.

Equipment	Flow (l/s)	Power(kW)
CDWP-PR-1	21.9	7.5
CDWP-PR-2	21.9	7.5
CDWP-SEC-1	23.9	15
CDWP-SEC-2	23.9	15

Table 10 Condensing water pumps specification

Equipment	Total capacity (kWr)	Flow (l/s)	Water entering temperature (C)	Water leaving temperature (C)	Power (kW)
CT-1	840	36.5	36.5	29.5	5.5

Table 11 Cooling tower specification

Equipment	Capacity (kW)	Flow (l/s)	Entering (C)	Leaving (C)	Consumption (MJ/h)
Boiler1&2	300	3.6	15	35	1175

Table 12 Boilers specification

Equipment	Rated flow (m^3/h)	Rated head (m)	Input Power (W)
HWP1-2	5	8	500

Table 13 Heating hot water pumps specification

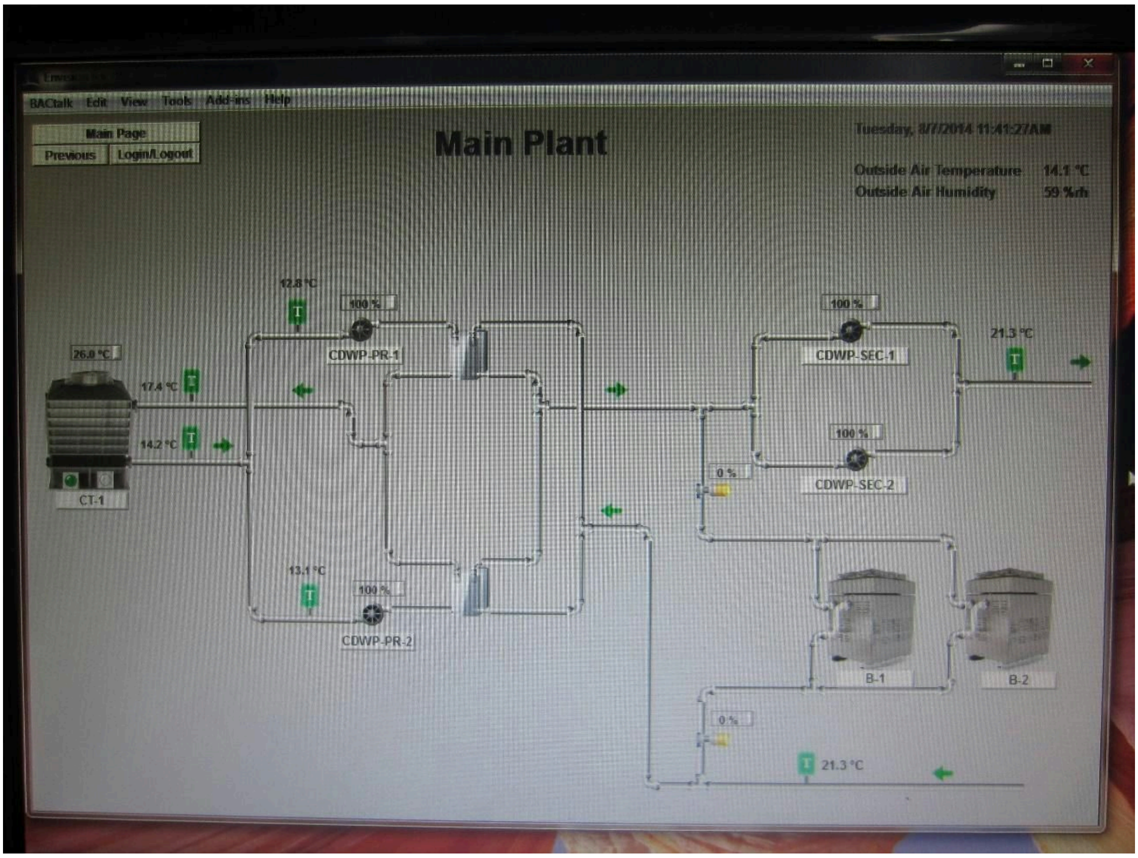

Figure 13 Schematic of the condensing water loop plant

6.1.3 General ventilation

There are two groups of toilets in the shopping centre and there are three toilet exhaust fans providing ventilation to these toilets. The specifications of these fans are listed in the table below.

Equipment	Air flow (l/s)	Static pressure (Pa)	Power rating (kW)
TEF-1	510	90	0.19
TEF-2	510	90	0.19
TEF-3	1490	120	1.39

Table 14 General fans specification

Lighting

6.1.4 Mall lighting

The general mall lighting is provided by a mix of 150 W metal halide with magnetic ballasts and 20 W halogen down lights. There are some skylights in the mall providing daylight to the general mall area as well. Pelmet lighting provided by 58W T8 fluorescent is present around the skylight and some shops. Lighting levels measured on site ranged from 220 lux to 340 lux. The details of the mall lighting are presented below.

According to the site manager, there is no security lighting circuit in this shopping centre so the mall lights are scheduled to run from 5AM to 3AM the next day. The only time these lights are switched off is between 3AM to 5AM every morning.

Unit	Nominal electric load (W)	Quantity
150 W metal halide down lights with magnetic ballasts	170	123
20 W halogen down lights	20	121
58 W T8 skylight pelmet lighting with magnetic ballasts	70	87
58 W T8 mall pelmet lighting with magnetic ballasts	70	45
400 W mercury vapour entrance downlights	422.6	10
Blue LED strip pelmet lighting	24 w/m	21 m

Table 15. Mall lighting details

6.1.5 Car park lighting

The car park is illuminated by twelve pole-mounted 1000 W mercury vapour lights. Due to the limited access to these luminaires, they are to be down lights. Car park lighting is controlled through BMS and is scheduled to switch on at 5:30 PM and switch off at 7:30 AM.

6.1.6 Exterior lighting

The exterior lighting is a mix of CFL oyster lights, mercury vapour down lights, metal halide down lights and metal halide wall flood lights. The details of the exterior lighting are presented in the table below. The exterior lighting is scheduled to switch on at 5:30 PM and switch off at 7:30 AM.

Unit	**Nominal electric load (W)**	**Quantity**
18W CFL Oyster lights	23.3	11
400 W mercury down lights	422.6	22
150 W metal halide down lights	170	18
100 W metal halide wall flood lights	114	16

Table 16 Exterior lighting details

6.1.7 Back of house lighting

The back of house lighting is present in the north mall corridor and the south mall corridor to the centre management office. These spaces are illuminated by a total of eight 2×36 W T8 bare battens with magnetic ballasts. The schedule for back of house lighting is the same as the mall lighting. They are only switched off between 3 AM to 5 AM each day due to the lack of the security lighting circuit.

6.1.8 Toilet lighting

There are two groups of toilets in the mall, the north mall group and the south mall group. There is one disable toilet, one parent room, one male toilet and one female toilet in the north mall. There is one male toile, one female toilet and one staff toilet in the south mall. The lighting in these toilets has recently been upgraded and they are generally provided by LED down lights. The details of the toilet lighting are presented in the table below. The toilet lighting is controlled through occupancy sensor. The occupancy sensor is located at the entrance of each toilet and there is no other sensors inside of the toilet.

Unit	**Nominal electric load (W)**	**Quantity**

11W LED Toilet down lights	11	74
14 W T5 fluorescent wall flood lights	16.5	5

Table 17 Toilet lighting details

6.1.9 Office lighting

The centre management office is illuminated by a total of twelve 1×36 W T8 recessed troffer with prismatic diffuser and magnetic ballast. These lights are controlled by manual switch.

Miscellaneous

The domestic hot water services for the base building is only available to the toilets. The tenants have their own electric domestic hot water services. There is no centralised domestic hot water plant. Boiling water units are used in each toilet to provide hot water. There are also some office appliance in the centre management office, including one fridge, one microwave, one dishwasher, one copy machine and a total of six desktop computers.

7 Appendix 3: HVAC System control

Mall air-conditioning units control

There are 7 mall units in total controlled centrally by the BMS. These units are on time-clock control. They are switched on at 6 AM in the morning and switched off at 6 PM in the afternoon on a normal weekday trading day according to BMS. The temperature set-points for all the mall units are a constant 22ºC.

The compressor stages against the temperature deviations are plotted in Figure 13. As can be seen from the graph, there is no dead band present in these units and the control of the compressor stages are erratic.

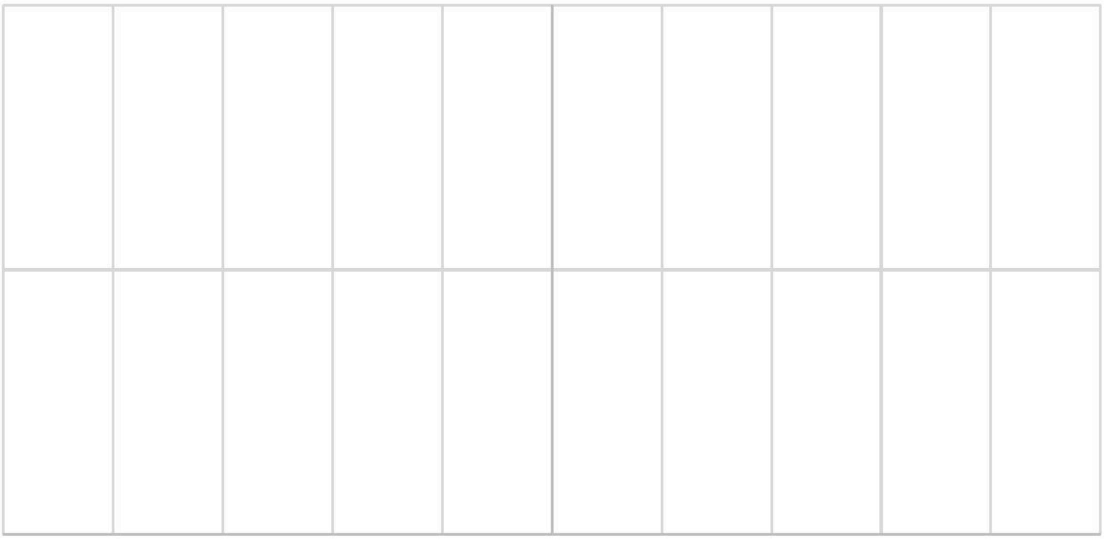

Figure 14 Mall units control

Condenser water loop control

According to the controls Functional Description, the condensing water loop is controlled based on the return condensing water temperature from the field on the secondary side. The primary condensing water pumps and cooling tower fan are switched on in stages when the return condensing water temperature exceeds the set point in heat rejection mode. The condensing boiler is switched on when the return condensing water temperature falls below the set point. The control strategy programmed in the BMS is presented in Figure 14. During the site visit, only one primary condensing water pump was running at 100% speed.

Note that given the gas consumption during summer, the controls may not be operating as expected.

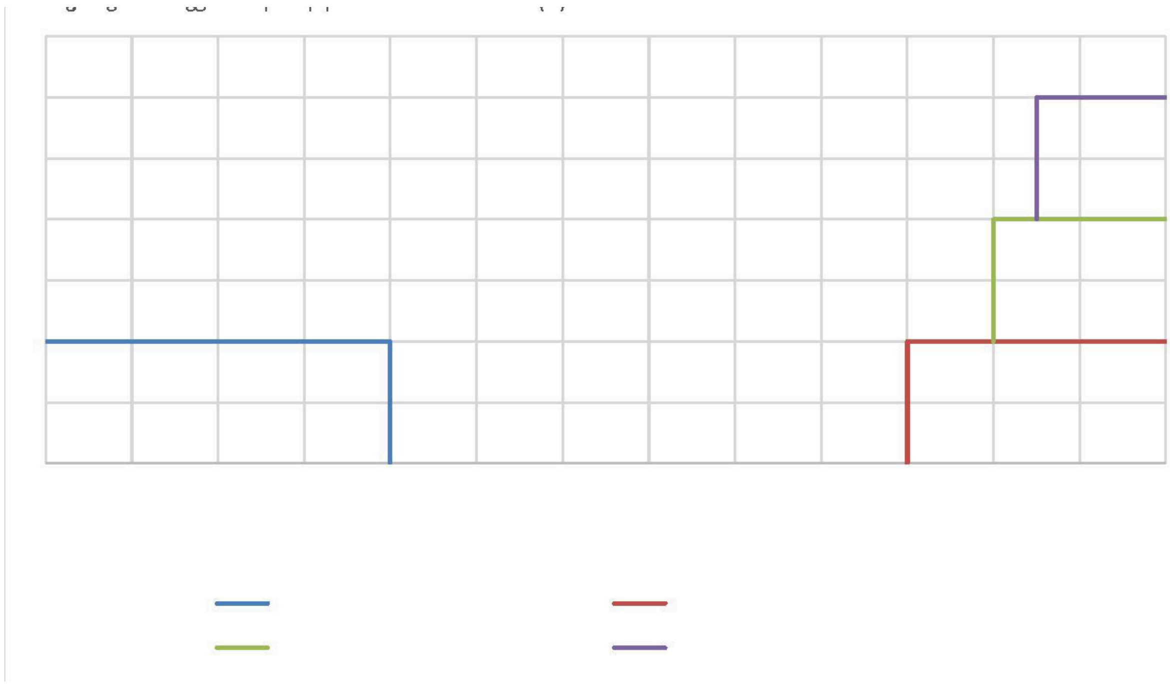

Figure 15 Condensing water loop control strategy

The secondary condensing water pumps are equipped with VSDs but there is no speed control algorithm. The two secondary condensing water pumps were observed running full speed during the site visit.

Tenant package units

The tenant package units are controlled by the tenants themselves with temperature set-points observed to range from 21ºC to 24ºC during the site visit. There are only a few tenant package units connected to the current BMS. However, the BMS can only display the fan status for these units. The BMS has no control for these units.

8 Appendix 4: Energy Management Practices

Aotearoa Park Ltd has a proactive stance on energy efficiency, with a goal to reduce energy consumption from 2010 levels by 25% by 2016. The building manager (Hone Smith) is responsible for the achievement of this target, and reports to the environmental manager of Aotearoa Park's parent company Global Retail Enterprises. Global Retail Enterprises maintains Corporate Social Responsibility reporting under GSREB.

We interviewed Hone Smith regarding the practices on site and note the following findings:

- Monitoring practices. Sub-meters are read manually by the embedded network operator and are largely used for on-charging. Although management maintains a record of manual readings, the lack of automated readings and time of use data represent a significant impediment to the use of this data for energy management purposes. Furthermore, the coverage of metering was not well designed for monitoring base building energy use from the perspective of efficiency. We have made recommendations to rectify this is Section 4.2.

- Reporting practices. The reporting practices for the site include a monthly report of consumption against benchmark from Aotearoa Park to Global Retail, but no further analysis is normally undertaken.

- Site documentation. On a site such as this it is not unusual to find issues with documentation, and this was the case. We found that documentation of tenancy refurbishments was generally lacking, with the result that there were significant questions regarding the nature of some parts of the tenancy air-conditioning systems in particular.

- Awareness, education and training. Hone Smith had excellent awareness of the site's energy efficiency policy and has been doing a good job in spite of having little training in the field. We recommend that he is offered the opportunity to expand his knowledge through further training in air-conditioning technology and energy monitoring.

- Process for energy efficiency investment. Aotearoa Park have a policy of considering all investments of less than 3 years payback. As shown in this audit, this is not necessarily compatible with their stated targets, particularly where deferred capital expenditure and maintenance issues are present.

- Existing sit energy efficiency activity. At present site energy efficiency activity is largely operational, i.e. management of time of use and rectification of obvious errors. The Site manager has also undertaken some ad-hoc improvements, particularly in the area of lighting. For the site to achieve its targets it will be necessary for a more aggressive approach to be taken.

- Maintenance. Maintenance standards on site were generally good, except in relation to tenancy air-conditioners, which were often difficult or impossible to access. As a result the standard of maintenance for these units is expected to be poor.

- Procurement policies. The site has no particular procurement policies in relation to energy efficiency.

Recommendations for the improvement of the energy management practices on site are provided in Section 4.