Feasibility Study
of
Hotel Energy Management System

For the

Victoria Hotel Melbourne

July, 2015

Experienced, Professional People at Your Service

Contents

1. Executive Summary 3
1.1. Introduction 3
NABERS rating improvement..3
1.2. Building cooling and heating system 4
1.3. Savings Summary 5
2. Recommendation 7
3. Energy Consumption..8
4. Energy Balance 11
5. Saving analysis 14
5.1. Energy Consumption..14
2. Energy Savings 14
1) BMS Implementation..14
2) EMS Implementation..14
3) Mechanical Ventilation with Economy Cycle..15
4) Foyer AC System Modification..15
5) Chiller Interconnection..15
6) Boiler Interconnection 15
3. GHG Emission Reduction 15
6. Project implementation cost 17
Cost of VSD only for the following pumps:..17
Cost of VSD only for the following fans:..17
Cost of BMS Implementation: 17
Cost of EMS Implementation: 17
The Mechanical Ventilation with Economy Cycle Costs: 17
Foyer AC System Upgrade Cost: 17
Chiller Interconnection Cost: 17
Boiler Interconnection Cost: 17
Field Equipment Cost..18
Electrical Installation Cost 18
Grand Total Project Cost is $311,798. 18
7. Appendix A..19
Table 1 - Full Asset List 20
Table 2 – List of major pumps and fans 23

1. Executive Summary

1.1. Introduction

This is a 3 ½ star hotel with 370 guest rooms. The hotel has a heated swimming pool, spa, gym and laundry. The NABERS rating for this hotel is 4 stars which is excellent. The hotel energy rating is high due to less energy use. This is primarily due to building construction, the walls are very thick and have very little windows and most of all there is no mechanical fresh air ventilation. All the AC systems are closed loop recirculated air with no ventilated air. All the fresh air is natural ventilation through infiltration.

The hotel consists of four buildings which are;

- Front centre building. The entrance to the lobby and reception is located in this building
- East wing building
- West wing building
- South wing building

Each building or wing has got only one chiller and one hot water boiler. If a chiller fails there will be no cooling to that wing. Interconnecting the chiller and hot water systems across the four buildings will provide standby or redundancy of equipment, overcoming many issues currently faced by the HVAC system. This project is highly recommended as it should be considered not just for energy saving but also to provide redundancy of the heating and cooling of the system in the hotel. As the chillers and boilers are serving one part of the building and if they fail the standby chiller and boiler will provide a backup system. Additionally it will substantially improve the comfort level in the building. Some of the building does not have a fresh-air system, the only ventilation is through the infiltration in the building

Table 1 Summary of Site Parameters

	Site Rating
Rated Hotel Quality Star Rating (AAA)	3.5
Current Energy Rating (NABERS)	4
Guest Rooms	370
Electricity Consumption	1,701,770 kWh/yr
Natural Gas Consumption	4,003 GJ/yr

NABERS rating improvement

The current unofficial NABERS rating is 4.5 star. Based on the NABERS reverse calculator, to improve the NABERS star rating by 0.5 (to 5 star NABERS) there needs to be an emission reduction of 1,897 tCO_2-e/yr. The energy savings projects proposed in this report are capable of reducing the GHG emissions from 2,519 tCO_2-e/yr to 1,787 tCO_2-e/yr. Therefore based on this unofficial calculation the Victoria Hotels NABERS start rating can increase from 4.5 to 5.

The official NABERS rating of the building is 4 star, but since then the energy consumption has decreased making it a 4.5 star building. When an official NABERS assessment is carried out, the Victoria hotel will increase its NABERS rating by 1 star form its current official rating.

1.2. Building cooling and heating system

All the guest rooms are cooled by chilled water circulation to the room with each room having a fan coil unit with the cooling and heating coil regulated by the room thermostat control. The heating is done by hot water circulation to the fan coil unit.

All the common areas are cooled and heated by reverse cycle units. All the controls are either on timer or manual control. All the auto control is discrete local control system. There is no BMS in the building and therefor no monitoring or automatic control of equipment. Any equipment faults are only rectified when there is a guest complaint.

The building has eight floors. Altogether there are eight lifts for guests and services

The lighting system: Most of the lamps have been replaced with LED lamps. There are still some conventional lamps such as dichroic down lamps and 36 wattage fluorescent tubes

Each building has its own chiller system, hot water system for space heating and hot water system for domestic hot water supply. The details of the main equipment is shown in Appendix A.

1.3.Savings Summary

The electricity reduction from the implementation of the opportunities outlined in Section 3, is expected to be around 31% of the total electricity energy consumption, with an expected reduction in peak demand of 10%. The gas saving is expected to be around 7% of the current gas usage. The following table summarises the outcomes of the study conducted. It is important to take into account the interactive effects of carrying out numerous projects. If all projects are selected for implementation the overall reduction in energy consumption will be lower due to the interactive effects between different equipment and systems at the site.

Table 2 Summary of Expected Energy Savings

Electricity		
Current Use	1,701,770	kWh/y
Saving	529,777	kWh/y
	51,119	$/y
	31.13	%
Gas		
Current Use	4,003	GJ/y
Saving	298	GJ/y
	4,287	$/y
	7.44	%
Demand		
Current Use	480	kVA
Saving	50	kVa
	3,890	$/y
	10.42	%
ERF Revenue		
Current ERF Spot Price	14	$/ESC
ERF Generated (reduction in tCO2-e/yr)	732	ESC/y
ERF Revenue	10,244	$/y
Total		
Saving & ERF Revenue	**69,540**	**$/y**
GHG Reduction	**732**	**t Co2-e/year**
Project Cost	**$311,798**	**$**
Payback Including ESC	**4.48**	**y**

2. Recommendation

It is recommended to implement the following energy saving measures.

1) Implement a non-proprietary BMS to control all equipment for building heating and cooling system
2) Install VSD's to the pumps without a VSD - See Appendix A, Table 2.
3) Install VSD to the following fans - See Appendix A, Table 2.
4) EMS
5) Introduce mechanical ventilation with economy cycle
6) Foyer/reception area AC system modification
7) Chiller Interconnection – List of cooling units in Appendix A, Table 1.
8) Boiler Interconnection - List of heating units in Appendix A, Table 1.

3. Energy Consumption

The hotel's energy consumption for the past 12 months from May, 2014 until April, 2015 is summarised in Table 3 below. The average variable energy cost for electricity and gas is only based on the components of the bill related to energy consumption. The relationship between the variable energy costs indicated that the electricity cost (including demand cost) is 2.32 times higher than the natural gas cost. Therefore it is more economically beneficial to direct energy savings activities towards opportunities which reduce the electrical energy consumption of the site.

Table 3 Energy Consumption & Cost Summary

Annual Energy Consumption	
Total Energy Usage (kWh/yr)	1,701,770
Maximum Contract Demand (kVA)	480
Average Variable Electricity Cost (\$/kWh)	9.65
Electricity Demand Cost (\$/kVA/month)	6.48
Total Gas usage (GJ/yr)	4,003
Average Variable Gas Cost (\$/GJ)	14.39

The electrical energy consumption of the site was found using electricity bills for the yearly period. The electrical energy consumption for the site for each month is shown in the table and graph below.

Table 4 Electricity Consumption each Month

Overall Electrical Energy Consumption (kWh/month)				
Month-Year	Peak Usage	Off-Peak Usage	Total Energy Usage	Total Cost ($/ kWh)
May-14	70,101	67,497	137,598	$ 17,026
Jun-14	62,406	58,674	121,080	$ 16,299
Jul-14	79,560	63,534	143,094	$ 14,356
Aug-14	73,056	72,946	146,001	$ 13,989
Sep-14	74,769	64,790	139,559	$ 13,840
Oct-14	78,941	66,122	145,063	$ 13,480
Nov-14	67,560	74,897	142,457	$ 14,080
Dec-14	73,301	67,461	140,762	$ 13,292
Jan-15	78,316	75,031	153,348	$ 13,496
Feb-15	71,829	73,204	145,032	$ 13,364
Mar-15	74,233	70,550	144,782	$ 12,527
Apr-15	76,430	66,564	142,994	$ 12,765
Total	***880,500***	***821,269***	***1,701,770***	***$ 168,515***

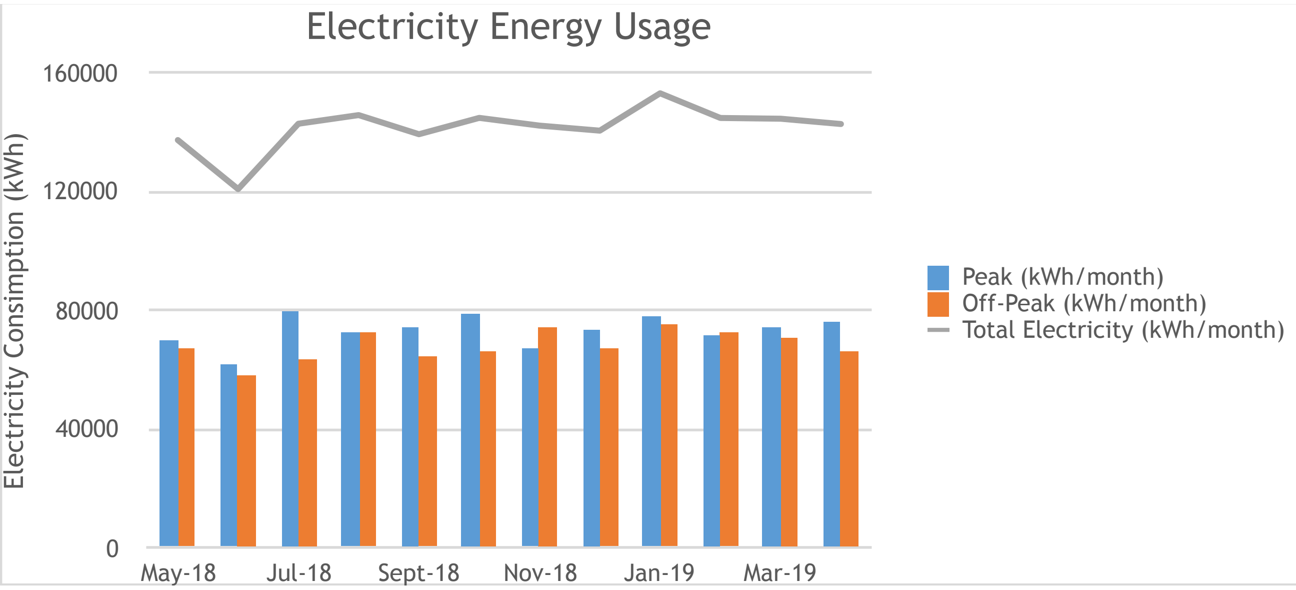

Figure 1 Electrical Energy Usage Profile

The natural gas consumption of the site for a 12-month period has been tabulated in Table 5 and the monthly usage profile is graphed in Figure 2 below.

Table 5 Natural Gas Consumption per Month

Month	Gas (GJ)	Rate ($/GJ)	Cost (Ex GST)
Apr-14	261	$9.69	$2,531
May-14	340	$9.69	$3,296
May-14	333	$9.69	$3,227
Jun-14	340	$9.69	$3,295
Jul-14	435	$9.69	$4,219
Aug-14	371	$9.69	$3,594
Sep-14	338	$8.30	$2,805
Oct-14	319	$14.11	$4,496
Nov-14	258	$14.11	$3,646
Dec-14	219	$14.11	$3,092
Jan-15	209	$14.39	$3,007
Feb-15	198	$14.39	$2,849
Mar-15	290	$14.39	$4,170
Apr-15	352	$14.39	$5,068
	4,003		***$49,296***

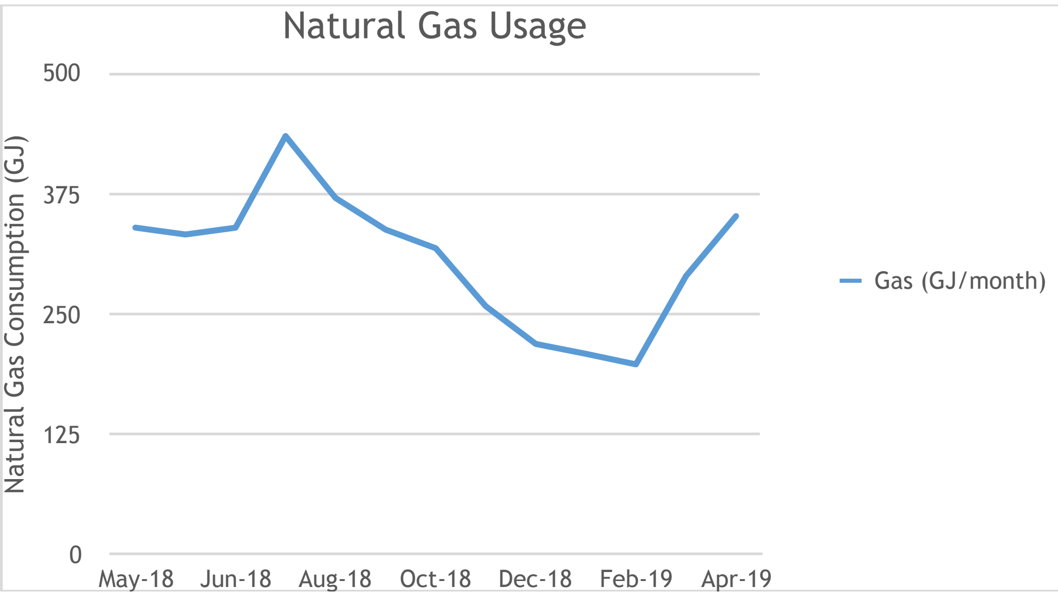

Figure 2 Natural Gas Usage Profile

4. Energy Balance

All the electricity consuming equipment at the site have been assessed to create a full energy balance of the end-used equipment. This is a built up asset list with estimated energy consumption calculations, the overall electrical energy consumption of 1,815,232 kWh/yr was compared to the actual consumption based on the bills 1,701,770 kWh/yr. The estimated energy consumption is 6.7% higher than the actual consumption so it can be confidently stated that the energy balance values are accurate. The results of the energy balance are given below.

Table 6 Energy Balance on Electricity Consuming EUE

EUE	Energy Usage (kWh/yr)	Energy Usage (GJ/yr)	Energy Balance (%)
Liquid Chiller	709,632	2,555	39.49%
Condensing Units	252,202	908	14.04%
Chilled Water Pumps	105,420	380	5.87%
Hot Water Pumps	53,676	193	2.99%
Reverse Cycle FCUs	56,566	204	3.15%
AHU	37800	136	2.10%
Curtain Heater	7560	27	0.42%
Exhaust Fans	118,944	428	6.62%
Lighting	275,000	990	15.30%
Lifts	180,000	648	10.02%
TOTAL	1,796,799	6,468	100.00%

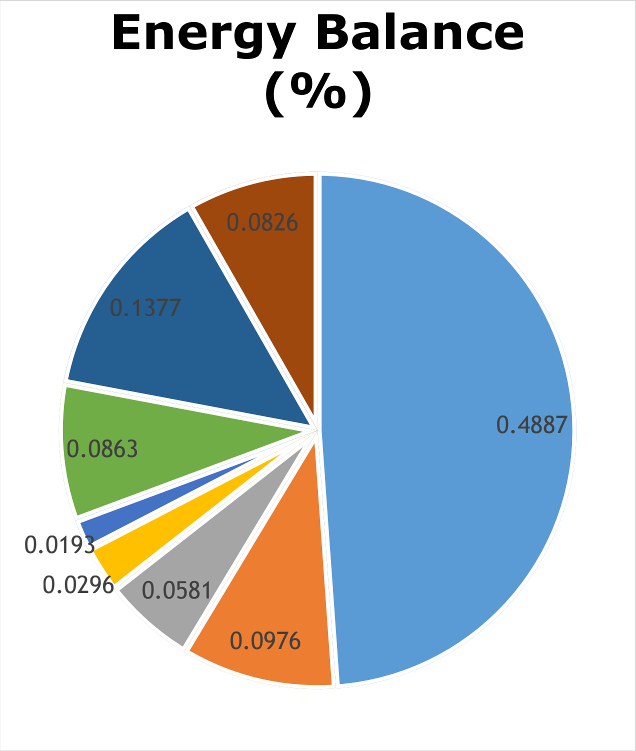

Figure 3 EUE Electrical Energy Usage Balance

The major users of natural gas are the boilers. As the two main objectives of using natural gas is for domestic use and space heating an energy balance on gas consumption is much simpler than electricity. The balance on natural gas consumption has not been split based on EUE, but based on its purpose as seen in Figure 4 below.

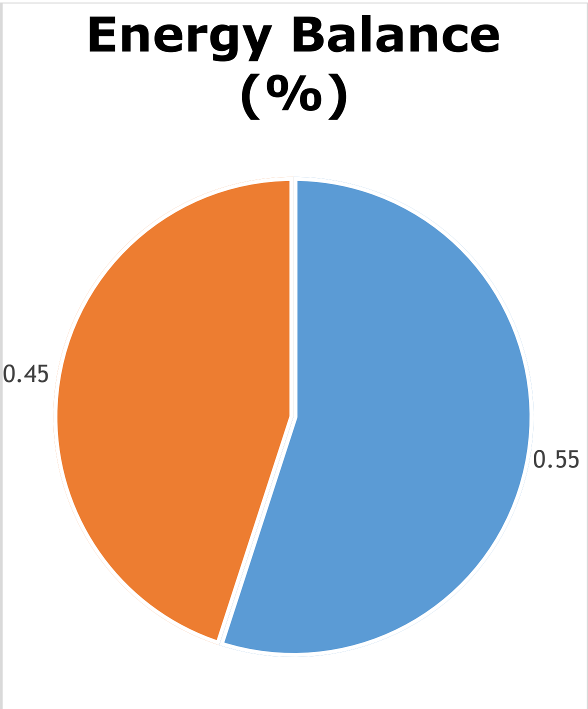

Figure 4 Purpose of Natural Gas Usage Balance

5. Saving analysis

An assessment of the Victoria Hotel has resulted in Enman finding a number of energy saving opportunities as given in section 2. Each energy saving project has been analysed to determine the amount of energy which can be saved from current operation.

5.1. Energy Consumption

First a full asset list was created with all major pumps and equipment, as well as lighting and lifts. The list is given in Appendix A, Table 1. The energy consumption of each item was found using the following equation:

2. Energy Savings

The asset list has the annual electrical energy consumption for all listed items. This along with the total gas consumption is then used to find the amount of energy savings which can be achieved by each project. Each projects ability to reduce energy consumption is summarised below:

1) BMS Implementation

Implement a non-proprietary BMS to control all equipment for building heating and cooling system. **Energy Saving:** This will reduce energy consumption of all equipment except lifts and lights by 8%.

2) EMS Implementation

Implement an EMS in conjunction with the BMS. The energy savings are divided as given below:

a) Liquid Chiller & Condensing unit.

Energy Saving: 18% saving on the energy usage by all the liquid chillers & condensing units.

b) Control existing VSDs on pumps

Energy Saving: 20% on pump operation if there already is a VSD on the pump.

c) Control new VSDs on pumps

Energy Saving: 35% on pump operation if a new VSD is installed onto the pump.

d) Control new VSDs on fans

Energy Saving: 35% on fan operation with a newly installed VSD.

e) Boiler Optimal Control

Energy Saving: 10% of all space heating related energy consumption.

f) Demand Management System

Energy Saving: 50 kW reduction on the contract demand.

g) Housekeeping

Energy Saving: 2% of overall electricity consumption.

3) Mechanical Ventilation with Economy Cycle

Introduce mechanical ventilation with economy cycle using new fans which will serve the large conference room and lobby area. This system will affect the cooling load of the three condensing units which supply this area.

Energy Saving: The energy consumption of the condensing units (3) used to cool the large conference rooms and lobby is reduced by 30%. So savings is only based on the cooling load and not the heating load.

4) Foyer AC System Modification

The cooling and heating system which serves the foyer area will need to be modified to avoid the different systems fighting against each other to heat or cool this area.

Energy Saving: 25% of heating and cooling of the condensing unit

5) Chiller Interconnection

The liquid chillers on the west wing building serve the west and south buildings. These two chillers are in the same plant room and need to be interconnected. Also there is one chiller on the front centre building serving this building, while there is another on the east building which serves the east building. These two chillers across the front centre and east building need to be interconnected.

Energy Saving: 10% of total liquid chiller energy consumption.

6) Boiler Interconnection

The west wing plant room has two boilers used for space heating. One of these boilers serves the west building, while the other serves the south building. These boilers need to be interconnected to improve the heating capacity for both building. Especially since the south building will be extended in the future to hold 80 additional rooms.

Energy Saving: 15% of space heating of the two Raypak boilers in the west wing plant room.

3. GHG Emission Reduction

The energy savings from these six projects is summarised in Table 7. The table also has information about the amount of GHG reduction (tCO_2-e/yr) which can be achieved by each project. This is calculated using the Australia NGA Factors (July, 2012). The relevant equations for electricity and gas energy-related savings is as follows:

Table 7 Project-based Energy Savings

Project	Energy Saving Factor	Energy Saving	Energy Saving	Overall Cost Saving	Reduction in GHG
		(kWh/yr)	*(GJ/yr)*	*($/yr)*	*(tCO2-e/yr)*
1) BMS Implementation	8% of all equipment operation, except lights and lifts	107,344		10,358	145
2) EMS Implementation					
a) Liquid Chiller & Condensing Unit	18% on the liquid chillers & condensing units	173,130		16,705	234
b) Control existing VSDs on pumps	20% on pumps with an existing VSD	15,540		1,499	21
c) Control new VSDs on pumps	35% on pumps with a new VSD	28,489		2,749	38
d) Control new VSDs on fans	35% on fans with a new VSD	54,860		5,294	74
e) Boiler Optimal Control	10% of space heating boiler control		180	2,592	10
f) Demand Management System	50 kW reduction			3,890	
g) Housekeeping	2% of electricity consumption	34,035		3,284	46
3) Mechanical Ventilation with Economy Cycle	30% saving of the cooling load for the conference room and lobby area.	5,473		528	7
4) Foyer AC System Modification	25% of the heating and cooling load of the condensing unit	39,942		3,854	54
5) Chiller Interconnection	10% of liquid chiller operation	70,963		6,847	96
6) Boiler Interconnection	15% of space heating of Raypak boilers on the west roof		118	1,695	7
TOTAL		***529,777***	***298***	***59,296***	***732***

6. Project implementation cost

The cost break down is categorised based on project or task as shown below. Under each heading is the itemised list of what is contributing to the project cost. The overall project cost is $311,798 (Ex GST).

Cost of VSD only for the following pumps:

- 1 x 5 kW CHW pump = $1,232
- 3 x 3kW HHW pump = $2,856
- 1 x 4 kW HHW pump = $1,078

Total cost of $5,166.

Cost of VSD only for the following fans:

- 1 x 5.5 kW KEF = $1,232
- 1 x 8.6 kW Restaurant EF & 1 x 9.5 kW Carpark EF = $3,766
- 1 x 7.5 kW Lobby Fan = $1,526

Total cost of $6,524.

Cost of BMS Implementation:

The price will includes all equipment and electrical works, for a total cost of ***$95,000***.

Cost of EMS Implementation:

If the BMS project is implemented the EMS implementation costs will be an additional ***$40,000***.

The Mechanical Ventilation with Economy Cycle Costs:

The cost to install two fans along with an economy cycle control will cost ***$7,228***.

Foyer AC System Upgrade Cost:

- Damper control for outside air duct = $4000
- Instrumentation = $1,000

Total cost of $5,000.

Chiller Interconnection Cost:

- 70m of piping = $25,200
- 8 x Isolation Valves = $28,800
- 4 x Balancing Valves = $14,400

Total cost of $68,400.

Boiler Interconnection Cost:

- 20m of piping = $7,200
- 2 x Isolation Valves = $7,200
- 2 x Balancing Valves = $7,200

Total cost of $21,600.

Field Equipment Cost

- 4 X DP Cells
- 7 X Temperature controllers
- 4 X CO_2 controllers
- 5 X Power meters
- Supply electricity meter connection

Total cost of $22,880

Electrical Installation Cost

Total cost of $40,000

Grand Total Project Cost is $311,798.

7. Appendix A

Key to Table 1:

- Front Centre Building = FC
- East Wing Building = EW
- West Wing Building = WW
- South Wing Building = SW
- Lobby = LB
- Conference Room = CR
- Car Park = CP
- Store Room = ST
- Server Room = SR

Table 1 - Full Asset List

Serv es	Description	Drive	No. off	Rated Capacity (kW)	Load Avg. (%)	Utilisati on Factor (%)	Energy Usage (kWh/yr)
FC	Hitachi Air-Cooled Chiller		1	127	0.33	1	352,044
FC	Raypak HW Heater		1	220	-	1	-
FC	Baxi Boilers		3	150	-	1	-
FC	Storage Tanks for hot water		3	0	-	1	-
FC	CHW Pump	VSD	1	5.5	0.5	1	23,100
FC	Grundforce HHW Pump		1	3	0.5	1	12,600
EW	Hitachi Air-Cooled Chiller		1	87.4	0.33	1	242,273
EW	Raypak HW Heater		1	220	-	1	-
EW	Baxi Boilers		3	150	-	1	-
EW	CHW Pump	VSD	1	7.5	0.5	1	31,500
EW	Grundforce HHW Pump		1	3.78	0.5	1	15,876
WW	Hitachi Air-Cooled Chiller		1	52.8	0.33	1	146,362
WW	Raypak HW Heater		1	170	-	1	-
WW	Baxi Boilers		3	65	-	1	-
WW	Storage Tanks for hot water		3	0	-	1	-
WW	Reverse Cycle FCU		1	5	0.5	1	21,000
WW	CHW Pump	VSD	1	5.5	0.5	1	23,100
WW	Grundforce HHW Pump		1	3	0.5	1	12,600
WW	CHW Pump		2	5.5	0	1	-
SW	Hitachi Air-Cooled Chiller		1	52.8	0.33	1	146,362
SW	Raypak HW Heater		1	170	-	1	-
SW	CHW Pump		1	5.5	0.6	1	27,720
SW	Grundforce HHW Pump		1	3	0.5	1	12,600
WW	Kitchen Exhaust Fan		1	5.5	0.6	1	27,720

WW	Restaurant Exhaust Fan		1	8.6	0.6	1	43,344
CP	Carpark Exhaust Fan		1	9.5	0.6	1	47,880
LB	Heating/Cooling units (Curtain Flow)		2	1.8	0.25	1	7,560
LB	Lobby Fan - Run by Reverse Cycle DX Condensing unit		1	7.5	0.6	1	37,800
LB	Reverse Cycle DX Condensing Unit. Temeprzone. 3 condenser fans. DX unit		1	31.7	0.4	1	106,512
CR	Reverse Cycle FCU		2	3	0.6	0.4	12,096
CR	Condensing Unit. R22.		1	5.7	0.5	0.4	9,576
CR	Condensing Unit. R22.		1	8.4	0.5	0.4	14,112
CR	Condensing Unit. R22.Split System.		1	1.5	0.5	0.4	2,520
CR-LB	Reverse Cycle FCU		1	1	0.6	0.4	2,016
CR-LB	Condensing Unit. R22.		1	4	0.5	0.4	6,720
ST	Reverse Cycle FCU		2	-	0	1	0
ST	Condensing Unit. R22.		2	-	0	1	0
SR	Daikin Split System. 2 Condensing nits.		1	3	0.6	1	15,120
SR	Panasonic Split System. Standby		1	3	0.6	0	0
Foyer	Hitachi Split System		1	3	0.6	1	15,120
Lights	Various		-	-	-	-	250,000
Lift			-	-	-	-	150,000

Table 2 – List of major pumps and fans

Serves	Description	Type	Drive	No. off	Rated Capacity (kW)
Front Centre Building	CHW Pump	CHW Pump	VSD	1	5.5
Front Centre Building	Grundforce HHW Pump			1	3
East Wing Building	CHW Pump	CHW Pump	VSD	1	7.5
East Wing Building	Grundforce HHW Pump			1	4
West Building	CHW Pump	CHW Pump	VSD	1	5.5
West Building	Grundforce HHW Pump			1	3
West Building	CHW Pump	CHW Pump		2	5.5
South Building	CHW Pump	CHW Pump		1	5.5
South Building	Grundforce HHW Pump			1	3
West Building Kitchen	Kitchen Exhaust Fan			1	5.5
West Building restaurant	Restaurant Exhaust Fan			1	8.6
Carpark	Carpark Exhaust Fan			1	9.5
Lobby	Lobby Fan - Run by Reverse Cycle DX Condensing unit			1	7.5