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- Adam Smith
- Carlo Boghdadi
- Rina Madden
- James Coffey

EXECUTIVE SUMMARY

The Szencorp Building at 40 Albert Rd, South Melbourne, is a unique green building refurbishment designed to demonstrate world leading environmental performance. Two years had passed and the building continues to improve in performance. Consumption is tracking to the design intent of the building and in some cases the building is operating better than expected. There have been a number of issues identified within the second year of operation and in many cases these issues have been resolved at the time of occurrence. One of the most challenging aspects of the second year operation of the building has been variable and low density occupancy. Consequently while the energy performance predictions from the first year have been beaten, the normalised emissions indicate a star rating of 5 star + 7.6% further reduction in greenhouse gas emissions.

This report is structured to address the following:

1. Review the recommendations of the first year building report
2. Investigate the performance of the changes made during the second year
3. Review second year performance in comparison to the building intent and first year performance
4. Provide recommendations for further fine tuning.

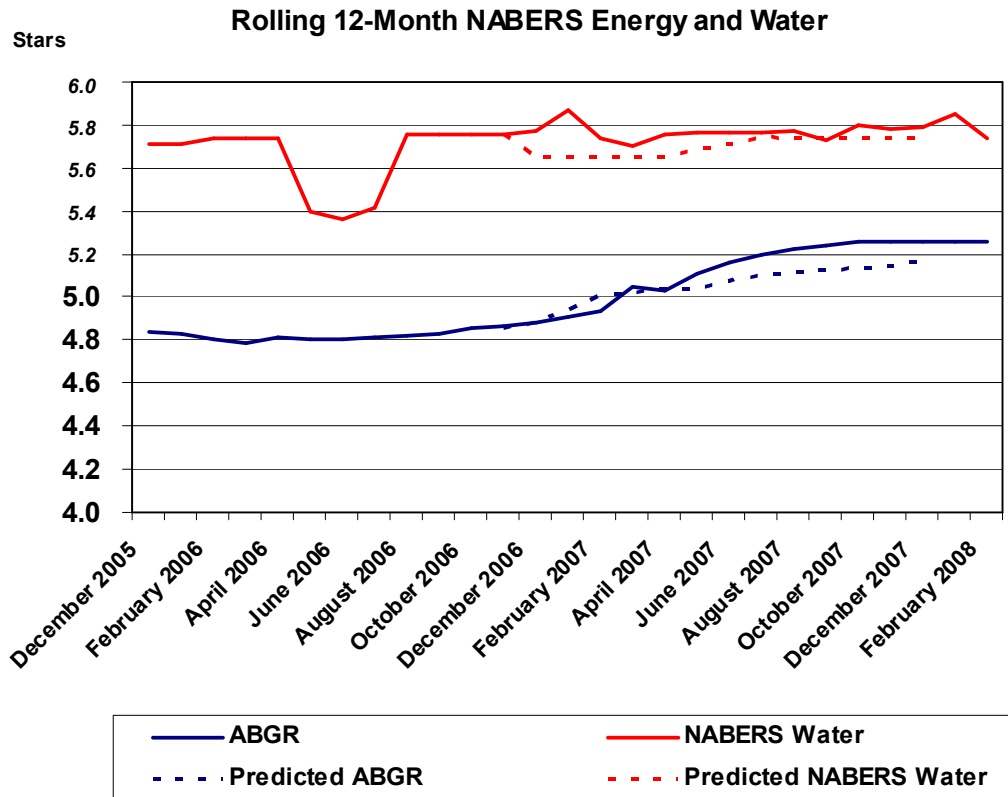
NABERS Office Ratings

NABERS Office (the National Australia Built Environment Rating Tool) is tailored for use by building owners, managers, and building occupants to rate the environmental performance aspects of the building, for example energy use (lifts, air conditioning etc), water consumption, light and power, transport to and from the building. The NABERS Water (water performance) and ABGR (energy performance) rating tools are calculated on a scale of 0 to 5 stars, with 5 stars representing the most efficient in building design and use.

The rolling 12 month ABGR and NABERS Water data has been updated to compare the second year actual performance against the predictions made in the first year building report. The calculation of star ratings for second year in this graph and in the table above are unofficial results as the second year ABGR application is due for completion and submission at the end of April 2008, see graph E.1 on following page.

In graph E.1, building performance data based on actual billing consumption up to February 2008 clearly indicates ongoing improvement in the performance of the building and 5 star ratings for both NABERS Water and ABGR. The performance data also indicates that not only has both 5 star ratings been achieved, but also that the performance is better than was required to achieve 5 stars.

Graph E.1: Rolling 12 month ABGR and NABERS Water



Dotted lines represent the expected ABGR and NABERS Water as predicted in the first year building report, while the solid lines indicate the actual results achieved during the second year operation of the building. Once again for clarity, the data used to build this graph is unofficial.

The improvement in building performance has been achieved through a number of measures, some identified within the first year building report and others identified and implemented throughout the second year, including HVAC system improvements, installation of additional pv arrays, lighting and control upgrades, BMS fine tuning and modifications to the domestic hot water and grey water systems. Full details of the measures taken to produce performance improvements are given within the corresponding sections of this report.

E.1 40 ALBERT RD - 6 STAR BUILDING

The 40 Albert Rd design was awarded a 6 Green Star rating based on a predicted 5 star Australian Building Greenhouse Rating (ABGR) and a commitment agreement was entered into to assure that the building would meet 5 stars ABGR. In March 2007 the NABERS Water and ABGR performance calculations were officially submitted to NABERS indicating successful achievement of the ratings as required through the commitment agreement.

In order to achieve the Green Star requirement of 5 star ABGR + 20% greenhouse gas emission reduction, the building needs to perform at or better than 136 kgCO₂/m²/annum. 40 Albert Rd has not achieved this and its current carbon dioxide emissions are at 158 tonnes of CO₂/annum, which is equivalent to 5 star ABGR + 7.6% reduction in greenhouse gas emissions.

This report contains a number of further energy saving measures for ongoing implementation as part of our goal to achieve the level of 5 star ABGR + 20% greenhouse gas emission reduction based on building design and management alone. 40 Albert Rd uses 100% green power, however for the purposes of assessing the performance of technologies installed in the building, 0% green power has been assumed in the rating calculations.

The pathway to 5 star ABGR + 20% greenhouse gas emission reduction involves a commitment to ongoing monitoring and identification of improvements. Achieving this goal will require a combination of energy conservation measures to reduce demand and also the installation of further embedded renewable generation to reduce requirements for imported energy.

E.2 PERFORMANCE TRACKING

Within the first year building report a prediction was made on the basis of energy performance estimates of the first year recommendations to project the building performance through the second year of operation. Table E.1 tracks the consumption performance of the building from design predictions, first year results, second year predictions and finally the latest second year performance figures.

Table E.1 40 Albert Rd performance tracking

	Electricity (MWh)	Gas (GJ)	Greenhouse Gas Emissions (tonnes)	Water (kL)
Ideal Case Design Intent	95	245	179	157
Worst Case Prediction	97	321	197	157
First Year Actual (from billing data)	74	367	176	121
Second Year Prediction (consumption as predicted in first year building report)	60	354	154	90
Second Year Actual (from 11 months billing data plus one month projected data)	68	286	151	76

The second year building performance has yielded very good results. These results are based on 11 months of actual data and one month of projected data. The ABGR ratings are unofficial as they will be submitted at the end of April 2008. The NABERS Water rating has been submitted. The energy and water performance of the building is analysed in full detail within the relevant sections of the report. There have been a number of system changes instigated during the second year operation in order to continuously improve performance.

The following table E.2 brings together both the consumption and ABGR and NABERS Water calculations from design through to second year projected performance.

Table E.2: 40 Albert Road ABGR & NABERS Water performance

		Design Predictions*		Actual Results**	
		Ideal Scenario	Worst Case Scenario	First Rating Year	Second Rating Year
Annual Electricity Consumption (MWh)		95	97	74	68
Annual Gas Consumption (GJ)		245	321	367	286
Annual Water Consumption (kL)		157	157	121	76
ABGR result	Stars	5.41	5.31	5.09	5.26
	Improvement over 5 star	5 star + 12.3%	5 star + 9.4%	5 star + 2.3%	5 star + 7.6%
	kgCO ₂ /m ² /annum	148	153	167	158
NABERS Water result	Stars	5.52	5.52	5.15	5.75
	Improvement over 5 star	5 star + 52%	5 star + 52%	5 star + 15%	5 star + 75%
	kL/m ² /annum	0.167	0.167	0.299	0.088

* Connell Wagner ABGR & Energy Report, 8th Reference 6103.01 Revision 5 - March 2005

** Energy data obtained from on-site metering system and retailer supplied data, second year is unofficial

The NABERS Water and ABGR scales are not directly comparable, consequently the decimal improvement for ABGR should not be compared against the decimal improvement for NABERS Water. In both cases the figures indicating above 5 star performance are an extrapolation from the rating tool and are in now way endorsed through the rating tools. In the case of percentage improvement over 5 star, for both NABERS Water and ABGR the percentage improvement reflects the actual performance as a percentage reduction against the level required in order to achieve 5 stars.

The significant improvement in the actual water consumption performance of the building in part reflects the lack of usage in the showers provided for staff members. This is due in part to reliability issues with the domestic hot water system and consequently lower than predicted staff usage of these facilities.

E.3 THIRD YEAR PREDICTION

From May 2008 it is expected that level 1 which is currently used for meeting and conference purposes on an occasional basis will become occupied by a new tenant. This occupancy is expected to increase the ratable building area and staff density with a lower than proportionate increase in energy and water consumption. Consequently the building is expected to yield improved ABGR and NABERS Water ratings when they are again submitted in 2009. The early projections for third year performance are produced in table E.3.

Table E.3 40 Albert Rd third year consumption prediction

	Electricity (MWh)	Gas (GJ)	Greenhouse (tonnes)	Water (kL)	Occupied Area (m2)
Third Year Prediction	100	340	205	95	1215

If the figures projected for the third year were achieved and the building operating hours remained at 55 hour per week, the corresponding ABGR star rating would be 5.39, equivalent to 5 star + 12% reduction in greenhouse emissions. This achievement would be entirely independent of further building system improvements and upgrades to reduce demand or increase embedded renewable generation. It is simply a reflection on increased staff density.

The prediction of third year consumption assumes that the four building levels currently occupied will continue to operate according to their existing performance characteristics. The occupancy of level 1 is projected to increase the electricity consumption for the building by 32 MWh. This will be the most energy intensive level of the building due to the high density occupancy. The overall building gas consumption is expected to increase to 340 GJ and the water consumption to 95 kL. The assumed consumption figures are conservative and it is expected that the building should achieve the 5 star + 12% performance at a minimum.

E.4 REVIEW OF FIRST YEAR RECOMMENDATIONS

There were a wide variety of recommendations tabled in the first year building report. All of these are reviewed in the corresponding sections of this report; the following in table E.4 on the following page identifies only those recommendations which were implemented during the second year and offers some performance data for each of the measures undertaken.

In a number of cases the emission reduction identified from data analysis before and after completion of each energy conservation measure shows a greater reduction than originally predicted.

See following page for table E.4.

Table E.4: Summary of the implemented first year performance improvement opportunities

Chapter	System	Recommendation	Predicted Cost Saving	Actual Cost Saving	Predicted tCO2 Saving	Actual tCO2 Saving	Benchmark Savings	Comment
2. HVAC and DHW system	Outside air-fan	Installation of motorised damper on the ground floor fan coil unit	\$90	\$90	1.0	1.0	\$1.32/m ²	See 2.2.3 for details
	Dehumidifier	De-commission the dehumidifier	\$29	\$135	1.96	2.4	\$0.11/m ²	See 2.2.2 for details
3. BMS	Car park exhaust fan	Car park exhaust fan on/off control based on CO levels	\$700	\$695	8.2	8.4	\$1.75/m ²	See 2.2.1 for details
4. Lighting & Lighting Controls	Halogen Lamps	Replace halogen lamps sources throughout the building with compact fluorescent	\$140	\$140	1.34	1.34	\$0.70/m ²	See 4.2.1 for details
	DSI Ballasts	Install controls to remove DSI standing energy losses	\$624	\$531	7.62	7.18	\$0.47/m ²	See 4.2.2 for details
5. On site Generation	None implemented							
6. Metering Systems	Gas & electricity meter installations on rooftop	Sub metering will improve ability to analyse equipment consumption and performance	\$0	\$0	0	0	N/A	See 6.2.1 for details
7. Water Systems	Flow restrictors	Maintenance required on taps and shower heads to ensure full compliance of to design specifications	\$0	\$0	0	0	N/A	See 7.2 for details
9. Lift	Lift Lighting	Install motion sensor in lift to control lighting	\$72	\$100	0.88	1.02	\$16.67/m ²	See 4.2.3 for details

E.5 RECOMMENDATIONS FOR FURTHER TUNING

Table E.5 provides the recommendations identified for further tuning. In many cases the identification of such improvements are analysed and implemented as a matter of course, consequently the items identified within this table are simply a reflection on the improvement works which are being considered at this point in time. Further to these items there are continued general recommendations which were identified in the first year building report and are still valid today, these are updated and re-produced in table E.6.

See following page for table E.5.

Table E.5: Recommendations for further tuning & works currently in progress

Chapter	Section	Recommendation	Capital Cost	Predicted \$ Saving	Predicted tCO2 Saving	Payback period	Comment
2. HVAC and DHW system	2.5.1	Identify and make improvements to the data collection and reporting functions of installed metering and sub metering systems	Unknown*	\$0	0	N/A	This recommendation is also tabled in the metering section of the report
	3.5.1	Installation of dedicated rain detection sensor to improve indoor environment for occupants	\$700	\$0	0	N/A	Existing rain detection is unreliable; the current sensor is an 'all in one' unit. Having a dedicated sensor will enable the collection of more accurate data on the amount of rain water used in the building.
3. BMS	3.5.2	Installation of new solar hot water circulation pump and upgrade of the system controls	\$3,500	\$650	4.5	5.38	This measure is expected to significantly increase reliability in the hot water systema and maximise the solar heat contribution
	4.5.1	Replace the incandescent lamps in showers with compact fluorescent	\$10	\$2.46	0.001	4.06	Figures based on approximation of occupancy throughout the year
4. Lighting & Lighting Controls	4.5.2	Modify car park detectors to combat against nuisance triggering	\$0	\$9.30	0.54	immediate	This measure reduces lighting power consumption in all common zones which are currently triggered when car park sensors detect movement
	4.5.3	Occupancy sensor masking to reduce nuisance triggering near enclosed offices	\$80	\$2.10	0.025	38	This recommendation addresses nuisance triggering of the enclosed office lighting for both occupant satisfaction and energy reduction purposes
5. On site Generation	5.6.1	Modify system to improve current poor performance of rooftop PV array due to shading	\$5000	\$265	2.9	18.8	This issue has be raised again for the second year building report however original recommendation information may also be found in the relevant section of the first year building report in Appendix A
	5.6.2	Installation of PV arrays to the remaining western facing windows	\$35,000 per level	\$265 per level	2.93 per level	132 per level	This recommendation serves a dual purpose, firstly providing shading to western facing office areas reducing cooling demand and increasing renewable energy generation by 6 MWh/year to improve the Building's ABGR performance.
	5.6.3	Regular ongoing monitoring and maintenance programme	N/A	N/A	N/A	N/A	A proposal for ongoing monitoring is to be issued in conjunction with the submission of this report.
6. Metering Systems	6.5.2	Re-instate the metering connections to BMS for rainwater capture and grey water recovery	\$150	\$0	0	N/A	In progress, this recommendation is also tabled in the water section of the report

* ECS will provide a proposal for the costing if this recommendation is to be pursued further by the 40Albert Rd.

The following general recommendations are included to ensure the ongoing performance and improvement of the building.

Table E.6: General recommendations

Operational Improvements	<p>Please refer to table E.5 for a list of all operational improvements identified in this report.</p>
	<p>Gas Sub-metering – While gas sub-metering has been installed and commissioned for the roof top systems, the tagging and meter identification through to the management review interface is less than ideal. The system should be reviewed such that the data can be more easily obtained and understood. Metering system upgrade recommendations are provided within the metering section of the report.</p>
	<p>BMS monitoring – Alarms currently generated by the BMS System appear to not adequately identify a level of severity associated with the occurrence, consequently there are a large number of minor occurrences creating a sense of apathy in operation. Such apathy may result in important alarms being occasionally overlooked. The rating system for alarms should be reviewed. BMS system upgrade recommendations are provided within the BMS section of the report.</p>
	<p>Metering/Alarm Settings – It is recommended that automatic alarm settings be configured for each meter within the building to send an email when a certain level is exceeded. This will assist to limit the effects of any faults or unexpected operation on the building’s overall performance. A solution to the ongoing monitoring and reliability of the monitoring system has been recommended and involves the setting up of a formal bureau metering service, thus ensuring commitment to building operation and improvement is fully supported.</p>
Management Improvements	<p>Regular performance benchmarking – It is recommended that an unofficial ABGR and NABERS rating be commissioned to be performed on a monthly basis, using a rolling 12 month total of energy and water consumption. This will help to ensure that performance targets are met</p>
	<p>Maintenance – An ongoing maintenance program is recommended to ensure all systems within the building are provided with the best chance of meeting performance targets. E.g. cleaning of photovoltaic panels, changing of FCU filters, etc.</p>

E.6 SUMMARY CONCLUSION

The Szencorp Building clearly demonstrates that 5 star energy and water performance can be achieved in an office building refurbishment using commonly available technology. Keeping the building operating at and above 5 stars has involved ongoing management and adjustments. Such improvement opportunities may not have been identified without a comprehensive BMS and metering system and the associated ongoing management to review building system performance.

The BMS and monitoring systems remain the greatest risk to the performance of the building as it continues to be the building's weakest link. Most of the second year recommendations are concerning the metering hardware, software and management review capabilities of these systems. Further fine tuning works are expected to yield only marginal operation efficiency improvements as both the energy and water performance figures indicate a leveling off over the past few months, however one particular aspect of the building operation is expected to reduce both the buildings normalised emissions and normalised water consumption.

In May 2008 it is expected that level 1 which is currently used for meeting and conference purposes on an occasional basis will be occupied by a new tenant. Such occupancy is expected to increase the ratable building area and increase staff density with less than proportionate increase in energy and water consumption. Consequently the building is expected to yield improved ABGR and NABERS Water ratings when they are again submitted in 2009.

INTRODUCTION

The Szencorp Building located at 40Albert Rd South Melbourne is a Six Star Design Green Star building. According to the Green Star rating, the building is the greenest building in Australia. However, to ensure that the building is performing in accordance with its design intent, the Szencorp group has contracted Energy Conservation Systems Pty. Ltd. (ECS) to conduct a performance audit on the building.

The objective of this Audit is to compare the building's current actual performance to both the first year performance and the original design intent. Identify any performance gaps, and provide recommendations to rectify these.

The scope of this project includes the collection and analysis of all available data relevant to the Szencorp building performance for the various systems outlined in table 1.1 below. This involves a comparison between baseline data, first year data and current performance of all these components. This report also outlines specific solutions recommended for implementation to improve both energy and water efficiency.

Chapter one analyses the building as a whole with relation to performance and where relevant, correlates the individual chapters and initiatives to existing national rating tools in the market: the Australian Building Greenhouse Rating (ABGR) and the National Australian Built Environment Rating Scheme (NABERS).

The report is separated into the following chapter headings. Independent studies separate to this report were undertaken for indoor air/environment quality (IEQ) as well as occupant satisfaction. The individual reports for these studies are available in separate reports.

Each section of the report is arranged in the following structure;

- Section title
- Brief introduction
- Summary of second year recommendations
- Review of first year recommendations and reporting of outcomes
- Detail of changes to system identified and implemented during the second year
- Review of second year performance, reporting and analysis of trend data
- Identification of future possible changes with details

Table I.1: List of Building Systems (& Document Chapters)

Chapter	Title
1	Overall Building Performance (including ABGR & NABERS)
2	Heating Ventilation and Air Conditioning (HVAC) & Domestic Hot Water (DHW)
3	Building Management System (BMS)
4	Lighting and Lighting Controls
5	Renewable Energy and On-site Generation
6	Metering System
7	Water Systems
8	Lift
APPENDICES	First Year Building Report

PATHWAY TO ZERO ENERGY BUILDING

40 Albert Road is targeting a goal to become a zero energy consumer. Such an achievement would require the on site generation of enough energy to power the building in its entirety and further on site generation for export to account for any import gas consumption. The on site generation must clearly be sourced from 100% renewable power and the technologies already in use will require supplementing with additional units and investment into new technologies.

In addition to further development of additional generation capacity, the ongoing commitment to reduction in consumption will continue, with modifications to solar hot water expected to further reduce gas consumption and a range of projects identified for the reduction of power demand. See Table E.5: Recommendations for further tuning & works currently in progress.

Technologies of specific interest for the building currently include;

- On site generation of hydrogen and the potential uses for hydrogen to reduce incoming gas
- Power generation from hybrid car linked into the building
- Further pv solar panels
- Development in micro wind turbine technologies
- Fuel cells

Of course, as new technologies are identified, all would be considered on merit for their potential to assist 40 Albert Road in achieving a zero energy building.

CHAPTER ONE | WHOLE BUILDING PERFORMANCE

The Szencorp Building at 40 Albert Rd was designed to meet the highest performance benchmarks in energy and water operational performance. The National Australian Built Environment Rating System (NABERS) is used to benchmark the building performance for water and energy/greenhouse efficiency. Australian Building Greenhouse Rating (ABGR) is the energy benchmark used within NABERS and is detailed herein. The building is rated as a “Whole Building” incorporating base building energy and water consumption plus tenancy energy consumption.

Conduct of the rating follows the NABERS protocols and has been completed by an accredited assessor. The NABERS water rating has recently been submitted for the rating period 1st February 2007 to 31st January 2008. The energy/greenhouse rating for the second year is due for submission in April 2008. In its place an ABGR assessment has been made for the period 7th March 2007 to 6th March 2008.

1.1 NABERS ENERGY AND WATER RATINGS

A NABERS rating has been performed on 40 Albert Road, which rates the relative efficiency of 40 Albert Road for energy and water efficiency. Table 1.1 shows the predicted and actual results for both ABGR (NABERS energy) and NABERS Water ratings.

Table 1.1: 40 Albert Road ABGR and NABERS predicted and actual results

	ABGR		NABERS Water	
	Stars	Normalised Emissions	Stars	Normalised Consumption
Pre-installation estimation*	5.41	148 kg CO ₂ /m ² /annum	5.61	0.137 kL/m ² / annum
Pre-installation worst case scenario*	5.31	153 kg CO ₂ /m ² /annum	5.61	0.137 kL/m ² / annum
First year performance period**	5.09	167 kg CO ₂ /m ² /annum	5.15	0.299 kL/m ² / annum
Second year performance period**	5.26	158 kg CO ₂ /m ² /annum	5.71	0.101 kL/m ² / annum

* Excerpts from the 40 Albert Rd ABGR & Energy Report (8th March 2005).

** Actual results have assumed 0% green power for the purposes of this analysis.

At 40 Albert Rd, 100% green power is purchased for electricity, and carbon credits offset the gas CO₂ emissions through Climate Friendly. Inclusion of green power and carbon offsets in the NABERS/ABGR calculation would automatically deliver a 5 Star rating, however for assessment of the energy efficiency of the building technologies through the NABERS/ABGR tools we have assumed 0% green power.

Table 1.2 on the following page displays the summary of inputs to the ABGR and NABERS Water rating tools. The following sections provide the calculation tool outputs.

Table 1.2: NABERS and ABGR calculator inputs for second year calculation

Rating Type	Whole Building	
Postcode	3205	
Rated Area	955	m ²
Rated Hours	50	hours per week
Number of Occupants	26.67	people
Number of Computers	29.67	computers
Electricity Account	67,766*	kWh
Gas Account	286,220**	MJ
Water Account	76	kL

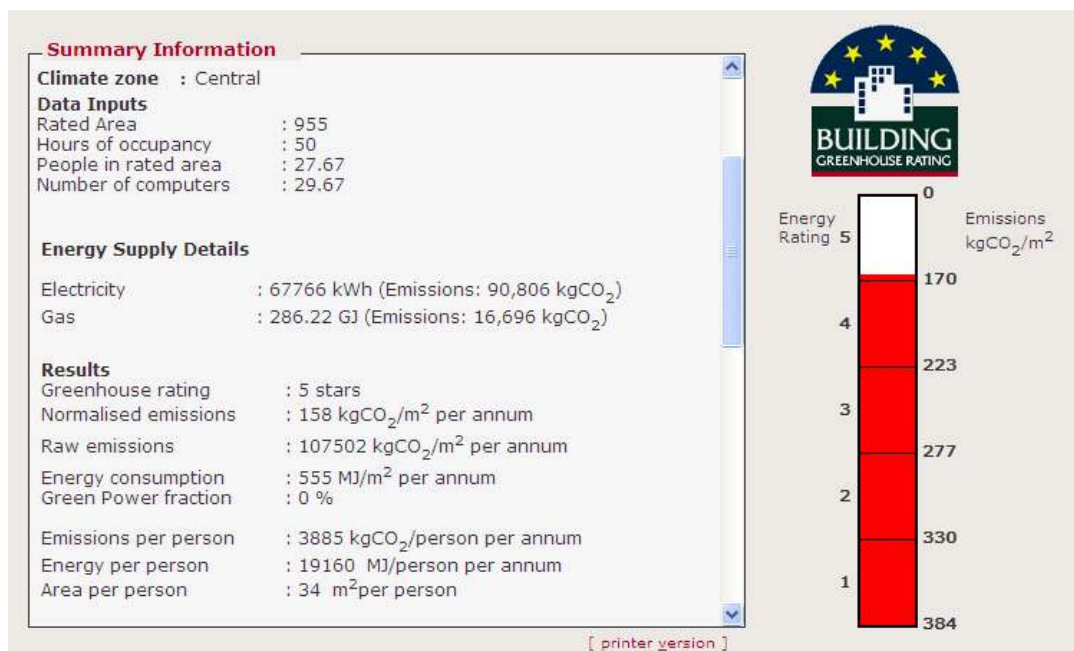
* 11 months of measured consumption, 1 month estimated

** 10 months of measured consumption, 2 months estimated

1.1.1 ABGR & NABERS Calculator Outputs

ABGR Energy

Image 1.1: ABGR Calculator Output



The normalised emission of 158 kgCO₂/m² per annum indicates a 5.26 star ABGR output. The official rating will be produced at the end of April 2008. The result is particularly encouraging as the building is sparsely occupied at the moment. New tenants on level 1 and predicted increased staffing levels for level 3 will reduce the emissions, energy and area per person ratios having a positive impact on the normalised emission and consequently ABGR rating output. The predicted increases are not expected to come into effect within the current rating period, rather will offer third year improvements in ABGR and NABERS Water.

The ability to achieve a high ABGR rating (independent of green power) while experiencing low density occupancy is a clear indication of the value of active and informed building management. To facilitate the identification and implementation of a large number of building system upgrades during the year the access to real time data trends has been vital. The improvement works identified and given immediate implementation during the second year period have been reported in detail within each section of the report corresponding with the particular services.

Extrapolating the predicted occupancy and corresponding consumption increases into the third year it is expected that the third year ABGR rating may be in the order of 5.39 with normalised emissions approximating 151 kgCO₂/m²/annum. Such a rating would still fall short of a 5 star plus 20% target which corresponds to a normalised emission of 136 kgCO₂/m²/annum.

NABERS Water

Image 1.2: NABERS Water Calculator Output



Water consumption through the second year of building operation has fallen below the predicted figures, however this is primarily due to reducing occupancy. The normalised water consumption as indicated in image 1.2 above is marginally better than the building's 0.09 kL/m² design intent at 0.088 kL/m² per annum.

1.2 DESIGN VS FIRST AND SECOND YEAR PERFORMANCE

Table 1.3: 40 Albert Road building performance

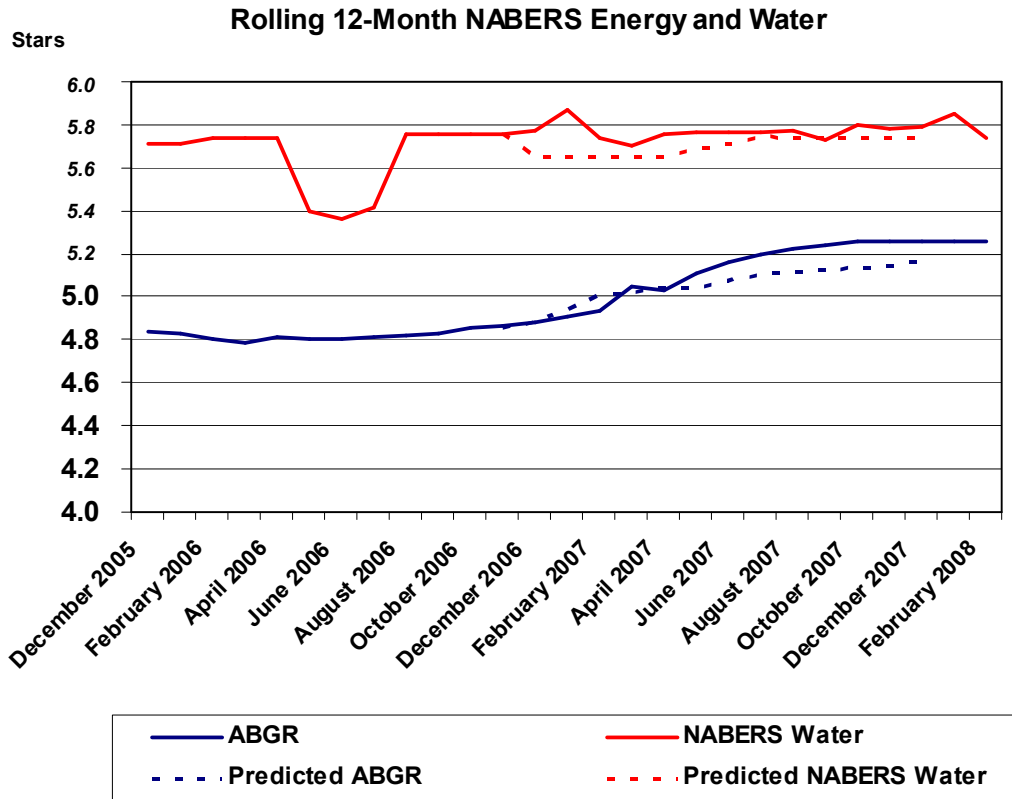
		Design Predictions*		Actual Results**	
		Ideal Scenario	Worst Case Scenario	First Rating Year	Second Rating Year
Annual Electricity Consumption (MWh)		95	97	74	68
Annual Gas Consumption (GJ)		245	321	367	286
Annual Water Consumption (kL)		157	157	121	76
ABGR result	Stars	5.41	5.31	5.09	5.26
	Improvement over 5 star	5 star + 12.3%	5 star + 9.4%	5 star + 2.3%	5 star + 7.6%
	kgCO ₂ /m ² /annum	148	153	167	158
NABERS Water result	Stars	5.52	5.52	5.15	5.75
	Improvement over 5 star	5 star + 52%	5 star + 52%	5 star + 15%	5 star + 75%
	kL/m ² /annunm	0.167	0.167	0.299	0.088

* Connell Wagner ABGR & Energy Report, 8th Reference 6103.01 Revision 5 - March 2005

** Energy data obtained from on-site metering system and retailer supplied data, second year is unofficial

A month by month assessment of the benchmarks can be made using a combination of measured consumption data as it becomes available with forecast consumption for remaining months. Analysis of this “rolling” benchmark shows improvement of the ABGR benchmark over time. The trend is displayed on graph 1.1 on the following page. This type of analysis has been used to review the performance of recommendations implemented from the First Year Building Report, the First Year Building Report predictions are compared with the actual results from billing data.

Graph 1.1: Rolling 12 Months NABERS Energy and Water



In graph 1.1 the dotted lines represent the expected ABGR and NABERS Water as predicted in the first year building report, while the solid lines indicate the actual results achieved during the second year operation of the building. The improvement in building performance has been achieved through a number of measures, some identified within the first year building report and others identified and implemented throughout the second year. Full details of the measures taken to produce performance improvements are given within the corresponding sections of this report.

1.3 ELECTRICITY CONSUMPTION

1.3.1 Electricity Overview

Table 1.4 on the following page demonstrates the Szencorp Building actual electricity consumption in comparison to the predicted design and worst case scenario consumption. Measured electricity consumption in second year is below the predicted consumption by 27MWh per annum.

Table 1.4: Building annual electricity consumption

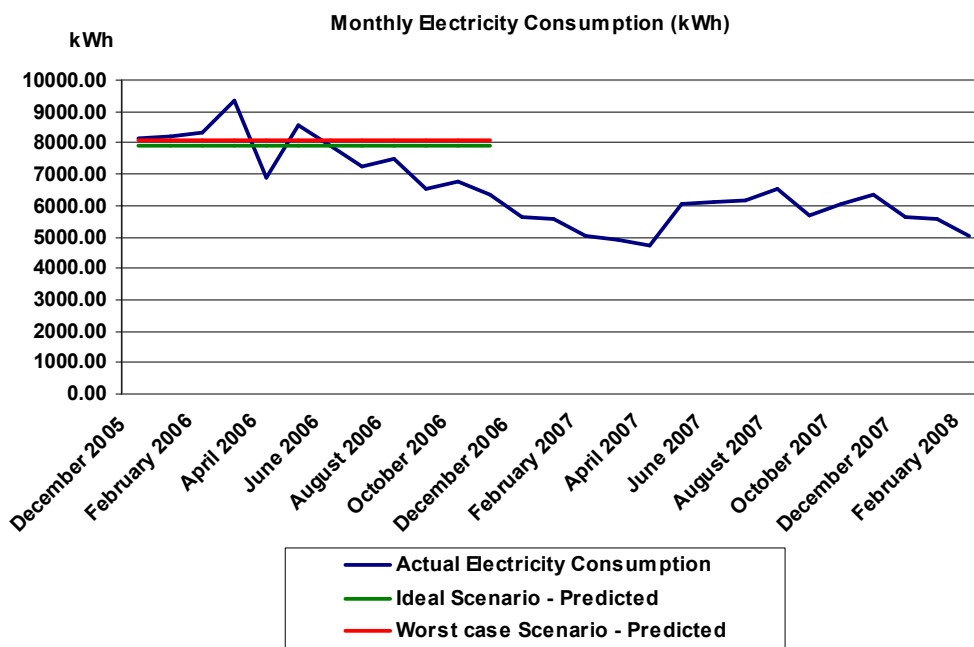
	Annual electricity consumption
Design case prediction	95,000 kWh*
Design case prediction – Worst case Scenario	97,000 kWh*
First Year Building Performance	73,926 kWh**
Second Year Building Performance	67,766 kWh**

* Source: 40 Albert Rd ABGR & Energy Report – 8th March 2005.

** Obtained from billing data

1.3.2 Electricity Performance

Graph 1.2: Building monthly electricity consumption



Graph 1.2 tracks the electricity consumption performance of the building from inception through to current day, the trend indicates a minor seasonal load with dipping consumption towards the end of summer where temperate weather allows for significant periods of free cooling during the day and night purge in the evening. During these periods the pumped cooling / heating circuits are off and the gas heat pump residual electrical and controls loads are low.

Table 1.5: Potential reasons for difference between designed and actual electrical consumption

System	Description	Effect
Lighting and ventilation	The designed annual electrical consumption assumed a fully occupied building with 54 occupants. Current occupancy is half of this, at 25. Occupancy based controls ensure that areas that are vacant are not lit or air conditioned, resulting in a reduced total building energy consumption.	Reduced electrical consumption from lighting and ventilation systems compared to designs
Ceramic Fuel Cell	The designed electrical consumption assumes that the ceramic fuel cell will produce a 1kW electrical supply to the building at all times, providing 9MWh of electrical energy to the building annually. The current electrical production of the ceramic fuel cell is zero. For further details on this component, please refer to Chapter 5 - On-site generation.	Increased electrical demand from grid of 9MWh compared to designs
Lift	Energy consumption by the lift is lower than that predicted. This is the result of lighting and lighting control system changes installed in early 2007.	Reduced electrical demand from lift.
Heat pump and Ceramic Fuel Cell	No electrical consumption was included in the design case for the fuel cell or heat pump units (except for the heat pump condenser fans). These components therefore increase the actual consumptions in comparison to the designed case.	The proportion of consumption for the second year is low as the Ceramic Fuel Cells were decommissioned during the year.

1.4 GAS CONSUMPTION

1.4.1 Gas Overview

Gas is consumed on site by two heat pumps, used for heating and cooling the building and an instantaneous gas Domestic Hot Water (DHW) unit which is designed to supplement the solar hot water collector. Table 1.6 shows the current annual gas consumption of 40 Albert road compared with predicted levels.

Table 1.6: Building annual gas consumption

	Annual Gas Consumption
Pre-installation estimate - Design Case	245,000 MJ*
Pre-installation estimate - Worst case Scenario	321,000 MJ*
First Year Building Performance	366,725 MJ**
Second Year Building Performance	286,219 MJ**

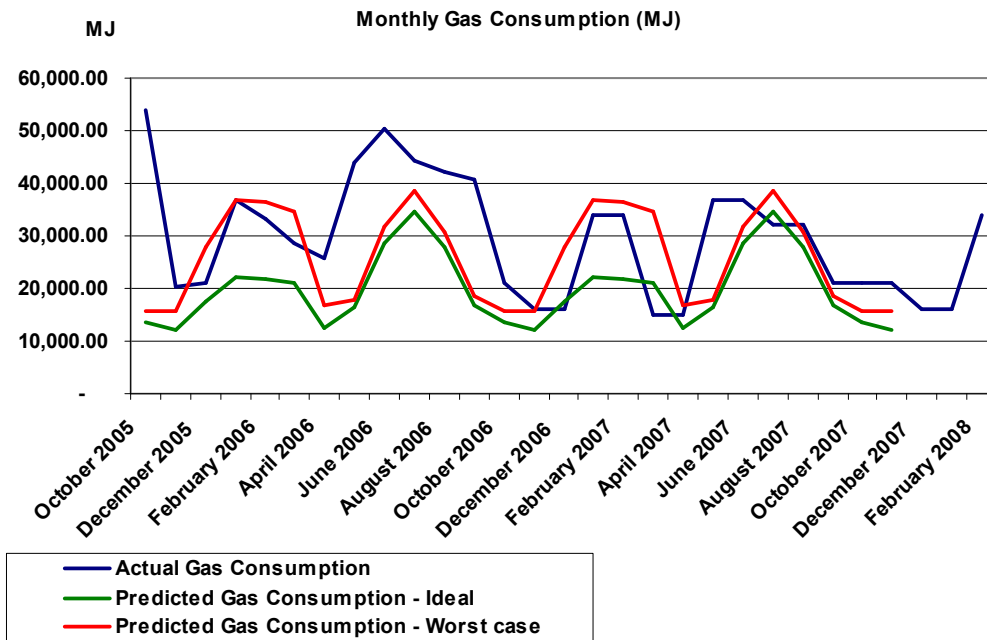
* Source: 40 Albert Rd ABGR & Energy Report – 8th March 2005. Worst case scenario refers to a possible worst case gas consumption based on unusual conditions caused by weather patterns, etc.

** Taken from 12 months of gas billing data

1.4.2 Gas Performance

The heat pumps are the main consumer of natural gas within the building, predicted at 83% of the building's consumption, and as such the total building consumption shows considerable seasonal change.

Graph 1.3: Building monthly gas consumption



Second year performance results better than the design intent for the building have been achieved through our commitment to ongoing improvements to the building services. There are further modifications recommended to improve the performance of the solar hot water heating, which would yield improved figures again for the third year building report to come.

The higher than expected gas consumption in October and November 2005 was attributed to the un-commissioned heat pump system running on full load for long hours. Final commissioning in November 2005 saw this consumption reduce to below predicted levels between December and March. The variance since commissioning was the subject of investigation into;

- Higher than predicted heating loads in the building
- Lower than predicted efficiency of the heat pumps in heating mode
- Higher than predicted consumption by the fuel cell
- High consumption by the domestic hot water system due to either lower than predicted contribution from the solar hot water system or higher than predicted hot water demand.

One of the First Year Building Report recommendations was to install metering on each of the gas appliances as previous to January 2007 there was not data available to identify the cause of higher consumption. Through the installation of metering it has been established that both the DHW and the Gas Heat Pumps are operating near design levels. The fuel cell had been consuming gas at a higher than predicted level. There have been a number of fine tuning alterations to the HVAC system which have produced further savings and it can be seen from Graph 1.3 that gas consumption is tracking close to the design intention.

1.5 WATER CONSUMPTION

1.5.1 Water Overview

Water is consumed by toilets, basin taps, sink taps in kitchens and showers.

Table 1.7: 40 Albert Road annual water consumption

	Annual Water Consumption	% Improvement over Design
Pre-installation estimated water consumption	157 kL*	-
First Year Building Performance	119.7 kL**	24%
Second Year Building Performance	76.4 kL**	51%

* Calculated by ECS water engineers during building design stage.

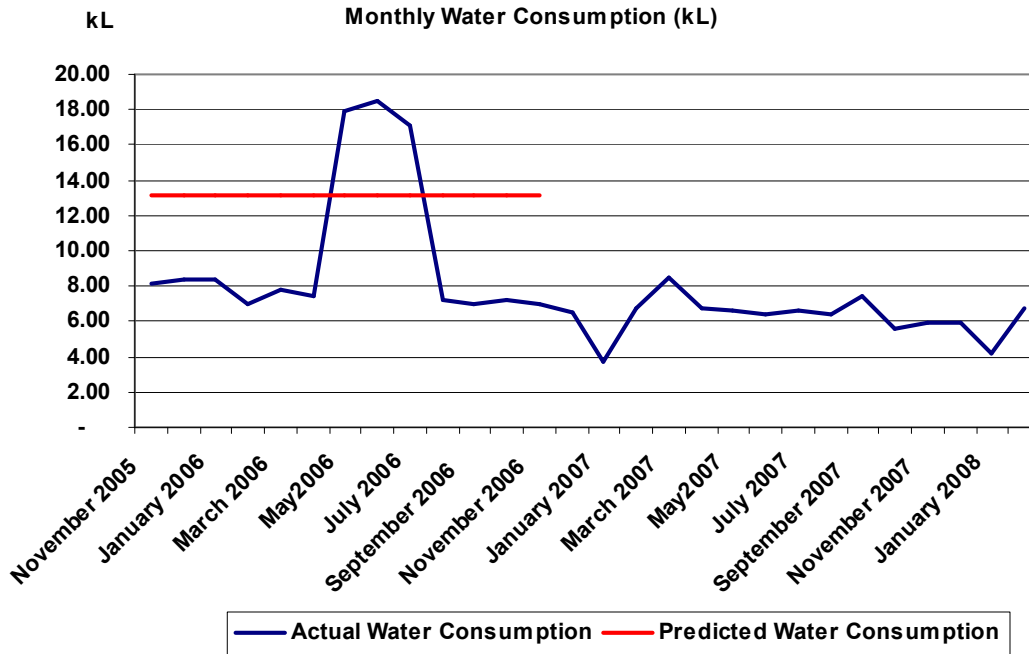
** Obtained from billing data

Water is supplied through a combination of piped town water, collected rainwater and recycled water. Actual building water performance indicates a 51% reduction in consumption against the design prediction and this represents a 75% reduction on the consumption target requirement to reach 5 Star NABERS Water. Such performance is due to a range of measures although a significant factor is the lower than expected usage of the staff showers. It is suspected that the reliability problems experienced with the domestic hot water system have impacted on staff attitudes toward usage of the showers.

1.5.2 Water Performance

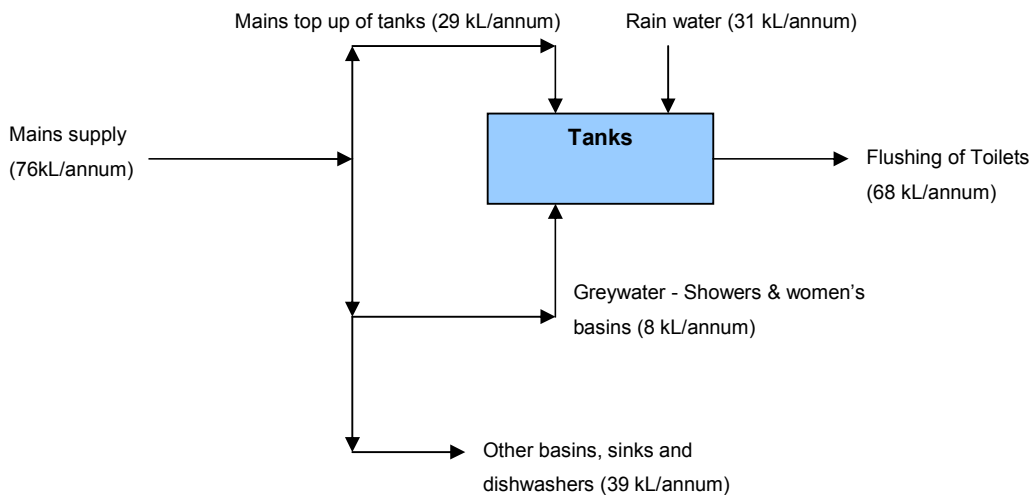
Graph 1.4 below shows the mains water consumption between November 2005 and January 2008. As identified in the First Year Building Report there was a water leak in mid 2006, resulting in increased consumption by approximately 30kL. Subsequent data indicates that the building maintains a stable consumption at approximately 7kL per month with a slight trend downward. This downward trend may simply be a result of decreasing occupancy figures across the year.

Graph 1.4: Building monthly water consumption



Further details of the site’s water systems are included in chapter seven. The water systems balance indicated in image 1.1 below provides an overview of building water movements. The figures are obtained by extrapolation as metering data for the full year is incomplete. In the second year water captured from rainfall has fallen by 6kL down to 31kL and grey water capture has fallen 4kL down to 8kL. These results are due to a period of failure in the old grey water system and the installation works associated with the new Nubian system. Further details are provided in chapter seven. Mains top up for toilet flushing has consequently increased, however total consumption for the building has performed above expectation.

Image 1.1: Second year water systems balance



1.6 TRANSPORT

The following components were included within 40 Albert Road to encourage staff to ride, walk or run to work:

- Two bike racks located in the basement car park and ground floor car park
- One bike rack located outside the front of the building
- Two showers located at the rear of the ground floor car park
- Staff lockers provided at the rear of the ground floor car park

During summer and spring, two staff members out of a total of 25 (8% of staff) regularly rode pushbikes to work, thus reducing greenhouse gas emissions, as shown in table 1.8.

Table 1.8: 40 Albert Road occupant transport methods

Mode of Transport	Number of Staff	Percentage	Comments
Car	19	76%	Down 1% from previous year
Staff with allocated car parks within the building	18	72%	
Staff who regularly require car for business purposes	5	20% (26% of car users)	
Bike	2	8%	1 also drives occasionally
Staff residences less than 20km from work	10	40%	Considered the maximum number of staff that could reasonably ride to work based on distance
Public Transport	6	24%	1 also drives several days per week
Walk	1	4%	Up 4% from previous year
Total Staff	25	100%	

The following services are available to encourage staff to ride public transport to work:

- Domain interchange tram station
- South Yarra train station
- Flinders Street train station

These are reasonably accessible, and provide most staff with the ability to reach 40 Albert Road from their private residences. Six staff within the building (24%) regularly use public transport to travel between home and work.

Explanations as to why more staff do not travel by bike, walk or running are as follows:

- Some staff are required as a part of their employment to use their own cars for business purposes. As such, their cars are required during the daytime.
- Many staff live far enough from 40 Albert road to prevent them from riding, running or walking.
- Several staff members have expressed dissatisfaction at the facilities provided for showers. The main concern has been the small size of the shower rooms, making movement restricted and a hassle. Notably, one of these regularly cycles to work.
- Some staff are unwilling to cycle during peak hour traffic, or are unwilling to ride due to health reasons.
- Some staff did not have any valid reason for not cycling to work. It is suspected that they are content with the ease and convenience of car travel.

Explanations for why more staff do not use public transport include:

- Staff who have a permanent car park allocated in the building find it less expensive to travel by car than to take public transport.
- Staff who have a permanent car park allocated in the building prefer the convenience of car travel.

Recommendations

If car travel is to be avoided in order to reduce greenhouse gas emissions by building occupants, alternative methods of transport should be encouraged. The following recommendation should be considered:

- Investigate the possibility of improving the shower facilities, perhaps incorporating an enclosed change room area adjacent to the showers
- Encourage drivers with allocated car parks within the building who do not require a car for work purposes to take public transport or cycle to work. Incentives could be in the form of a bike allowance for purchase of cycling gear, or an interest free bike loan.
- Remove allocation of car parks from those staff who do not require a car for work purposes.
- Provide a building-wide focus on health and fitness. This might include sponsorship of staff participation in sporting events such as the BRW triathlon, Melbourne marathon, 'Run to the G', 'Around the Bay in a Day', etc, possibly with a Szencorp team focus.

It is also recommended that staff use smaller cars that produce less greenhouse gas emissions. It was intended that the small size of car park spaces in the building would encourage staff to drive smaller vehicles, but at present this does not appear to have made any impact. The following ideas have been suggested by staff:

- For those staff required to use their cars for business purposes, provide the option of salary sacrifice on small vehicles.
- Impose a limit or carbon tax to be paid by staff on cars that exceed a 2.5 Litre engine size.

1.7 INTERNAL BUILDING ENVIRONMENT

Within recent months 40 Albert Rd has been testing a new technology installed on level 3 which is designed to mask noise in the form of conversations travelling through the work space. The product has operated for a number of months and during that time there have been a series of tests conducted to establish the performance and effectiveness of the units. The results to date indicate that the actual effectiveness of the unit within this environment is quite low and may in some cases actually contribute to unwanted noise level.

Further testing of the product may be necessary to establish the true effectiveness of the unit in an environment more suited to its application. One of the key factors leading to the perceived failure of this equipment to perform is that 40 Albert Rd already operates at a base noise level sub 40 dBA and this product is designed to provide effective noise masking around 47 dBA, consequently the masking frequencies emitted from the unit are clearly audible by occupants. Setting the units to operate sub 40 dBA appears to have no discernable impact in masking conversation from travelling.

On occasion at 40 Albert Rd with the windows open, street noise contributes to increase the average base sound level can rise up to approximately 43 dBA, measured on level 3. It is of course highly variable depending on vehicle movement and time of day, however the sound level remains too low for the operation of the masking technology.

The application of this technology in an office space may produce reasonable masking performance where the base load is in the region of 48 – 55 dBA, for example a call centre or similar. For Green Star buildings however, this technology is unsuitable as the Green Star sound level requirement is sub 40 dBA.

1.8 BUILDING PERFORMANCE CONCLUSIONS

The Szencorp building:

- has achieved 5 star NABERS Water performance in the second year of operation and continues to show positive trends in water use awareness and reduction in consumption
- has achieved 5 star performance ABGR in the second year of operation
- both 5 star ratings were achieved with a significant margin
- Further recommendations of development of the monitoring systems are required to ensure that in the event of failure excessive consumption is quickly identified and stopped.

CHAPTER TWO | HVAC AND DHW SYSTEM

This chapter addresses the performance of the Heating Ventilation and Air Conditioning (HVAC) and Domestic Hot Water (DHW) system.

The HVAC system provides effective service to the occupants of the building and is equipped with all the known effective energy saving techniques to operate as a very efficient system. There were however, a number of fine tuning tasks identified through completion of the *First Year Building Report*.

The DHW system has continued to operate with variable success, it is designed for operation on solar and has back up gas fired units. The solar equipment has been modified after recommendations from the *First Year Building Report* however the performance still remains lower than expected. A further complication was the tendency for the gas hot water unit to fail to adequately back up the system while the solar is unavailable. This was recently identified as an issue with the reliability of gas pressure on the supply to this unit and the system has been rectified.

2.1 HVAC AND DHW SYSTEM SUMMARY

Table 2.1: Recommendations for performance improvement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Identify and improve the data collection and reporting functions of installed metering	Unknown*	\$0	0	N/A	In order to identify further energy saving measures in the future, more reliable and higher quality data is required. This measure is also included in the metering section of the report.

* ECS will provide a proposal for the costing if this recommendation is to be pursued further by the 40Albert Rd.

2.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

Table 2.2 below provides a record of all of the identified HVAC and DHW recommendations from the First Year Building Report. For full details of the basis of these recommendations the full text of the First Year Building Report is provided in Appendix A.

Table 2.2: Table of all First Year HVAC and DHW System recommendations

Recommendation	Capital Cost	Annual \$ Saving	Annual CO ₂ Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Car park exhaust fan on/off control based on CO levels	\$700	\$695	8.2	1.0	This is also included in the BMS chapter	Implemented See 2.2.1
De-commission the dehumidification unit	\$0	\$29	1.96	Immediate	Deemed unnecessary in this building.	Implemented See 2.2.2
Outside air fan energy reduction by installing motorised damper on the ground floor fan coil unit	\$900	\$90	1.0	10.0	This is currently not in place and once installed will allow the OAF VSD to reduce fan speed and deliver savings	Implemented See 2.2.3
Use of high efficiency motors during replacement	N/A	\$40	0.48	N/A	This is recommended when fan motors fail and require replacement.	No motor replacements
Installation of CO ₂ sensors to reduce fresh air intake thus reducing cooling/heating energy	\$8,000	\$210	1.8	Very High	This may not be feasible due to low returns.	Not implemented
DHW pumps operational control to eliminate pumps running unnecessarily	\$780	\$23	0.27	33	This should be done when the system is fully commissioned	Not implemented
Gas heat pumps stand by power control based on building occupancy.	\$1,500	\$250	5.1	6	This will require confirmation of viability from Mitsubishi Heavy Industries.	Not implemented

Of the recommendations identified within the First Year Building Report changes were made to the following systems;

2.2.1 Car park exhaust control

Car park exhaust fan control through the use of carbon monoxide sensors was installed for both the basement and ground floor car parks. This system allows control of the car park exhaust fan only when extraction is required, rather than based on timer control. This system was expected to produce savings of \$700 in reduced electrical consumption, 8.2 tonnes of carbon emissions and a payback of one year. The following table 2.3 summarises the performance of this energy control measure.

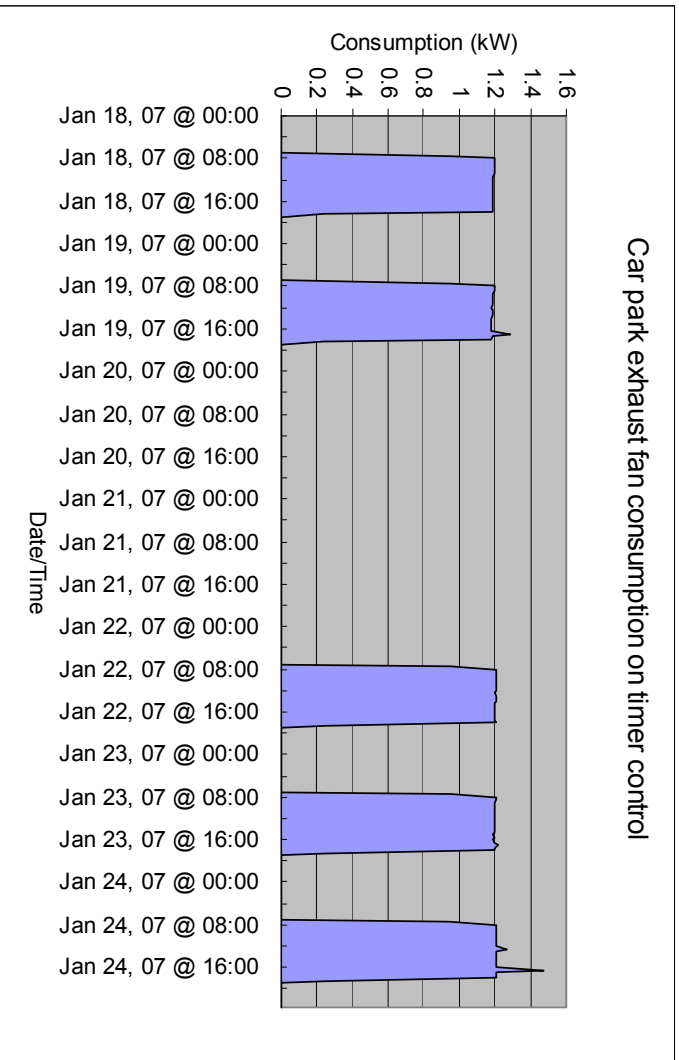
Table 2.3 Results of Energy Control Measure – Car park exhaust control

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO ₂ Reduction	Actual tCO ₂ Reduction*
Car park exhaust fan on/off control based on CO levels	2 nd Feb 2007	\$700	\$695	8.2	8.4

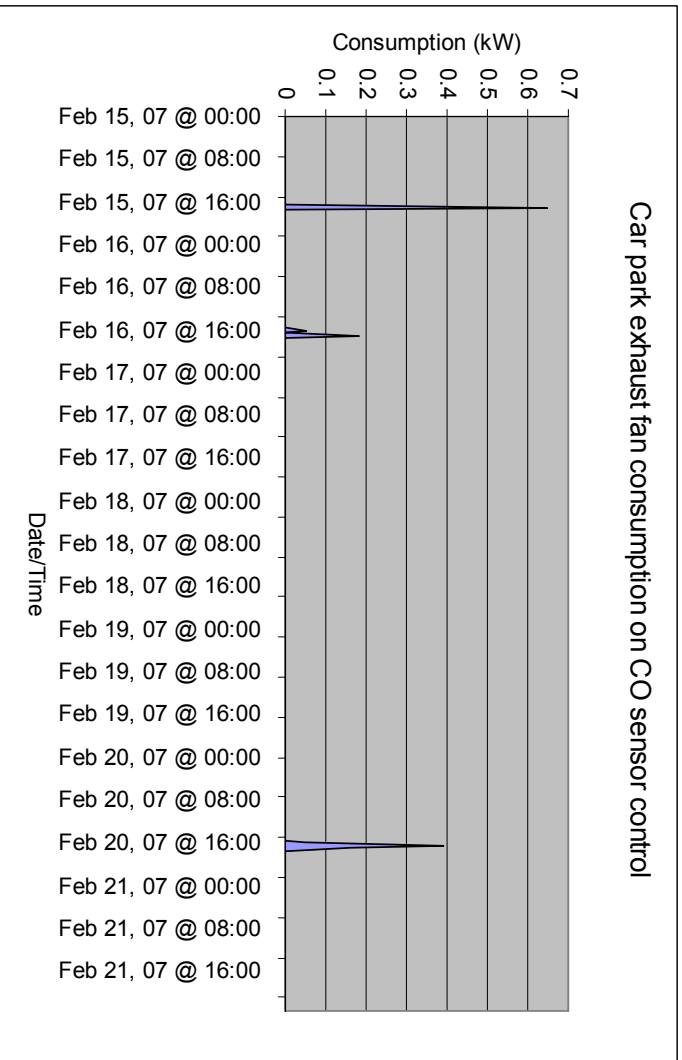
* Figures for carbon emission reduction from the First Year Building Report were based on the emission factor 1.467 kgCO₂ per kWh, valid at the time of reporting, the current figure of 1.444 kgCO₂ per kWh for imported Victorian electricity reflects changes and development within the Victorian electrical generation market.

The following graphs 2.1 to 2.3 clearly indicate the difference in consumption between timer control and CO sensor control. Graphs 2.1 and 2.2 show the weekly exhaust fan consumption profile for the week before and after the energy control measure implementation. Graph 2.3 compares a daily profile of timer and CO sensor control.

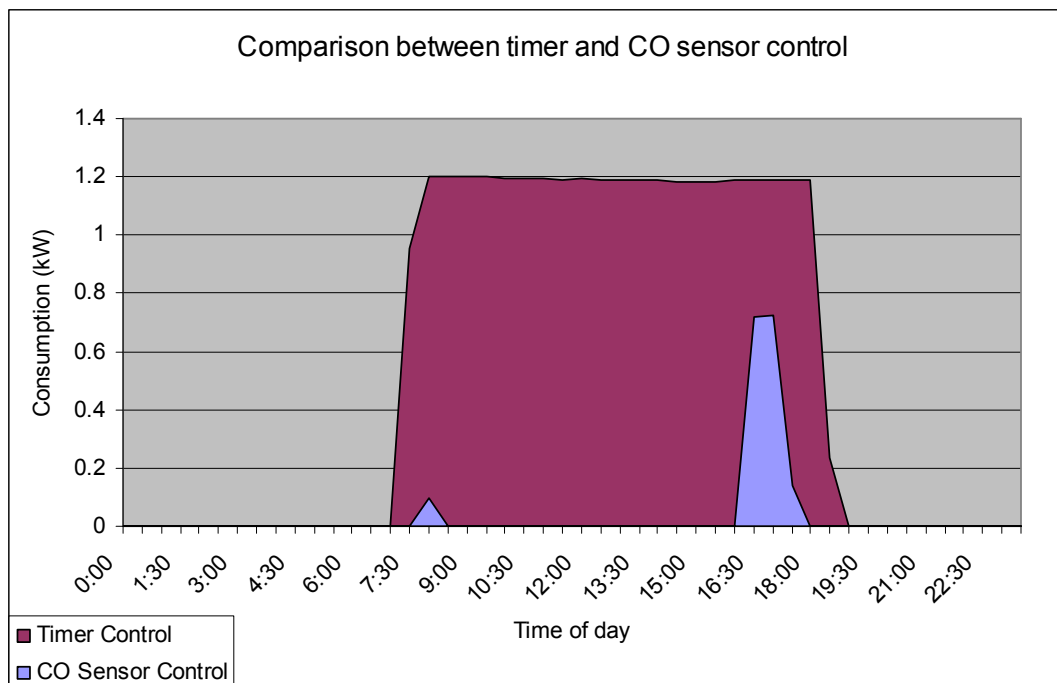
Graph 2.1: Weekly consumption profile on timer control



Graph 2.1: Weekly consumption profile on CO sensor control



Graph 2.3: Daily load profile comparison between timer and CO sensor control



Based on Timer control, the consumption of power for the car park exhaust fan remains constant at approximately 26.2 kWh per day for each business day of the year. Based on 50 weeks this yields an annual consumption of 6,625 kWh.

The actual consumption identified after the completion of installation works for the CO sensor are better than predicted, with an average consumption of 2.98 kWh per day. This figure changes daily according to the number duration and frequency of CO detection events. The data indicates the actual savings in electrical consumption based on this energy control measure is 6,029 kWh, a reduction of 91%. (7th March 2007 to 6th March 2008 total consumption against this meter was 596 kWh)

The reduction in electrical consumption during peak import tariff returns a saving of \$796.43, paying back investment under one year and reducing carbon emissions by 8.38 tCO₂.

Figures for carbon emission reduction from the First Year Building Report were based on the emission factor 1.467 kgCO₂ per kWh, valid at the time of reporting, the current figure of 1.34 kgCO₂ per kWh for imported Victorian electricity reflects changes and development within the Victorian electrical generation market.

2.2.2 Decommission of the dehumidification unit

The Dehumidification Unit was decommissioned in early 2007 and no longer consumes energy. The following table 2.4 summarises the performance of this energy control measure.

Table 2.4 Results of Energy Control Measure – Decommission of the Drykor Unit

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO ₂ Reduction	Actual tCO ₂ Reduction
De-commission the dehumidification unit	Early 2007	\$29	\$135	1.96	2.4

Due to the exceptional indoor environment quality at 40 Albert Rd the use of dehumidification and air filtration has not enhanced air quality, consequently the operation of the dehumidification plant was deemed to be a waste of energy and this unit has been decommissioned.

The data from the First Year Building Report indicates the consumption of this unit was 3,270 kWh and the performance of the unit negligible as most of the run hours were required for satisfying weekly maintenance programme, rather than actual dehumidification operation. Its decommissioning produces a significant saving in energy, a cost saving of \$135 and reduced carbon emissions by 2.4 tCO₂.

A marginal increase in gas consumption by the gas air conditioning was projected due to the change in air properties and an approximation based on historical data for air humidity in Melbourne comes to approximately 32 GJ or \$298. The increased gas consumption figure and associated carbon emission is included within the calculations for Table 2.3, consequently the figures in table 2.3 represent the overall savings achieved through implementation of this energy control measure. Gas consumption data indicates that actually the total gas demand has actually decreased and it is not possible to obtain a numerical value for the change in gas use attributable to the dehumidification decommissioning alone.

2.2.3 Modifications to the ground floor fan coil unit

On the 31st January 2007 a fresh air damper was installed on ground floor. The purpose of this energy control measure was to reduce the power demand on the outside air fan for this zone. This energy conservation measure relies on the ability to optimise the outside air damper with the operation of the fan coil unit (FCU21). The fan speed changes according to the static pressure sensor in the duct work. Previously, fresh air was provided to the ground floor regardless of occupancy on the ground floor (i.e. air was forced through the FCU even when the FCU was off). The following table 2.5 summarises the performance of this energy control measure.

Table 2.5 Results of Energy Control Measure – Installation of ground floor damper

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO2 Reduction	Actual tCO2 Reduction
Outside air fan energy reduction by installing motorised damper on the ground floor fan coil unit	31 st Jan 2007	\$90	\$90	1.0	1.0

Without individual zone metering it is not possible to specifically identify the performance specific to this energy control measure separately from the total energy reduction produced through the combined effect with other changes to the system.

2.3 SECOND YEAR HVAC AND DHW SYSTEM CHANGES

2.3.1 DHW modifications to meter and pipe work

During 2007 the DHW system was investigated in order to identify the cause of an occasional failure to produce hot water. During the summer the system relies on solar gain as the primary heat source with top up achieved through gas water heating. In winter when relying on the gas water heating the system would often fail to deliver and after some investigation it was identified that the problem was flame failure through pressure loss. The pressure drop appeared to be caused or perhaps compounded by the pipe work surrounding the metering installation completed in January 2007. In early 2008 the system pipe work and meter location was modified to reduce the severity of the pressure drop. Consequent performance of the DHW system is much improved.

2.4 SECOND YEAR HVAC AND DHW CONSUMPTION ANALYSIS

The HVAC and DHW consumption for analysis of second year building performance is tabulated in the corresponding sections below for gas and electrical consumption. Individual metering was installed as a recommendation from the First Year Building Report and consequently there is no first year data available for comparison.

2.4.1 Gas Equipment Consumption

Gas consumption for the HVAC and DHW equipment is metered individually through metering installed after recommendation in the First Year Building Report. The meters have been logged into the OnTrac system and data is available from February 2007. Table 2.6 below indicates the monthly gas consumption as metered for each appliance at 40 Albert Rd, this data is graphed on the following page, graph 2.4.

Table 2.6 Monthly Gas Consumption Data

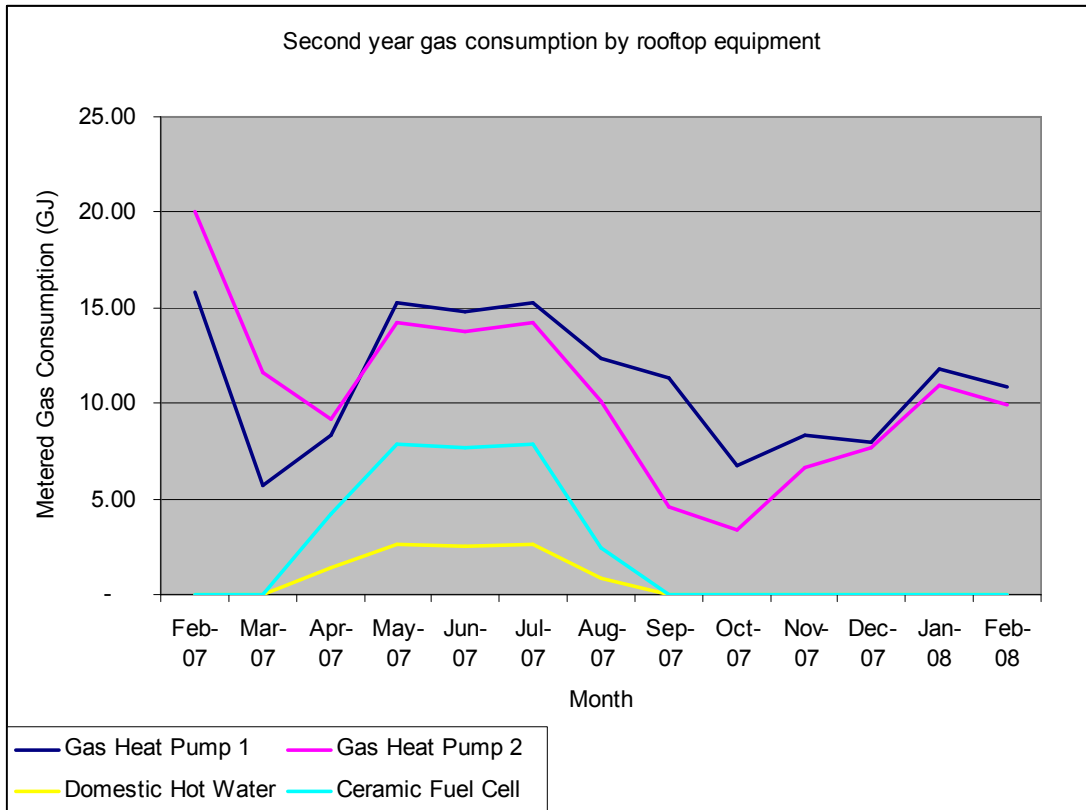
Gas Appliance Identifier	Gas Heat Pump -1 (Meter 300548)	Gas Heat Pump – 2 (Meter 300543)	Domestic Hot Water (Meter 300546)	Ceramic Fuel Cell (Meter 300547)
February 2007	15,802.18	20,061.67	-	-
March 2007	5,686.37	11,651.12	-	-
April 2007	8,311.67	9,217.53	1,408.89	4,192.66
May 2007	15,242.36	14,229.06	2,652.03	7,892.08
June 2007	14,766.04	13,784.39	2,569.16	7,645.45
July 2007	15,242.36	14,229.06	2,652.03	7,892.08
August 2007	12,356.73	10,093.35	828.76	2,466.28
September 2007	11,324.01	4,594.20	-	-
October 2007	6,703.76	3,334.00	-	-
November 2007	8,364.03	6,611.09	-	-
December 2007	7,926.47	7,668.47	-	-
January 2008	11,824.53	10,992.09	-	-
February 2008	10,828.67	9,926.25	-	-

* Data is natural gas consumption records in megajoules (MJ)

The gas air conditioning system has a full year consumption of 244.91 GJ for the year, 7th March 2007 to 6th March 2008. The billing data for the equivalent period indicates a site total consumption of 309.8 GJ, consequently the gas air conditioning is consuming 79% of the total gas to site. This proportion of use is likely to have increased as the fuel cells are no longer consuming gas. The actual consumption of 244.91 GJ for the gas air conditioning compares very closely with the original design worst case scenario prediction of 242 GJ. The assessment made for the first year building report of 420.41 GJ is likely to be an error based on the lack of data at the time and that consumption for the fuel cell was greater than originally projected. This was discussed in detail in the first year building report.

Consumption for the gas air conditioning varies with season however operates all year round as the units are producing both heating and cooling as required. The lower consumption months are in shoulder seasons when the weather is temperate. Graph 2.4 indicates the consumption profile for gas air conditioning, DHW and the fuel cell through the second year.

Graph 2.4 Second year gas consumption by rooftop equipment



Of the total billed gas consumption for the building, DHW production shows a gas consumption of 10.11 GJ and monthly analysis shows consumption only in winter months when the solar water heating is less effective or unavailable.

2.5 RECOMMENDATIONS FOR FURTHER TUNING

2.5.1 Metering review and upgrade of reporting functions

Interrogation of the rooftop HVAC and DHW services are limited by the accuracy and quality of data available through the installed metering system. On trac has failed to adequately identify, record and display meaningful electrical data for the roof top services in a format simple enough to be easily understood. With particular reference to meters labelled “roof top unknown” the system integrity is severely reduced. In some cases “virtual meters” have been created which produce data by addition or subtraction of other meters. These are not adequately identified from the ‘real’ meters and consequently the ‘real’ data can no longer be read as reliable.

Table 2.7: Recommendations for performance improvement - Metering

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments
Identify and improve the data collection and reporting functions of installed metering	Unknown*	\$0	0	N/A	In order to identify further energy saving measures in the future, more reliable and higher quality data is required. This measure is also included in the metering section of the report.

* ECS will provide a proposal for the costing if this recommendation is to be pursued further by the 40Albert Rd.

CHAPTER THREE | BUILDING MANAGEMENT SYSTEM (BMS)

This chapter evaluates the performance of the Building Management System (BMS), an Alerton system utilising a Tridium Bacnet interface to the mechanical services, and low level interfaces to other systems. The BMS as a system has evolved with continual commissioning and programming changes to improve building control and performance.

3.1 BUILDING MANAGEMENT SYSTEM SUMMARY

Table 3.1: Recommendations for performance improvement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Installation of dedicated rain detection	\$700	\$0	0	N/A	This measure is designed to improve the indoor environment for occupants
Installation of new solar hot water circulation pump and upgrade of the system controls	\$3,500	\$650	4.5	5.38	This measure is expected to significantly increase reliability in the hot water systems and maximise the solar heat contribution

3.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

There have been numerous controls software changes on the BMS system over the past year addressing a wide range of building performance enhancements. The BMS is fundamental to the efficient operation of the building and nearly all energy saving measures which have been implemented over the last year have at some stage required a level of integration into the BMS. The following table 3.2 indicates the First Year Recommendations for the BMS system.

Table 3.2: Table of all First Year HVAC and DHW System recommendations

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Modify software to switch off car park exhaust fans when CO levels are below 8ppm	\$700	\$695	8.2	1.0	This is also included in the HVAC and DHW chapter	Implemented See 3.2.1

Modify software to disable the outside air fan on each floor for the first 30 minutes of occupancy when night-cooling mode has operated during the night	\$1,500	\$72	0.088	20.0	The costs for this modification may possibly be reduced once Alerton have evaluated the required changes. This will also reduce the payback period.	Not Implemented
3.2.1 Car park exhaust control						

This energy saving measure was implemented with outstanding results. The following table 3.3 summarises the performance of this energy control measure. The full details can be found within the HVAC & DHW chapter, section 2.2.1.

Table 3.3 Results of Energy Control Measure – Car park exhaust control

Recommendation	Date Implemented	Predicted Cost Savings	Predicted tCO2 Reduction	Actual Cost Savings	Actual tCO2 Reduction
Car park exhaust fan on/off control based on CO levels	2 nd Feb 2007	\$695	8.2	\$695	8.4

3.2.2 Log the HVAC heating / cooling modes

Although not specifically costed and tabled as a recommendation within the First Year Building Report, this simple measure was completed. As such it is now possible to identify the run hours for heating and cooling modes of operation individually at every fan coil unit within the building. This measure itself has no impact on the consumption of power, other than providing useful information for the analysis of plant operating modes.

3.3 SECOND YEAR BUILDING MANAGEMENT SYSTEM CHANGES

Further to the BMS modifications identified within the previous building report there have been a large number of fine tuning changes required throughout the second year operation.

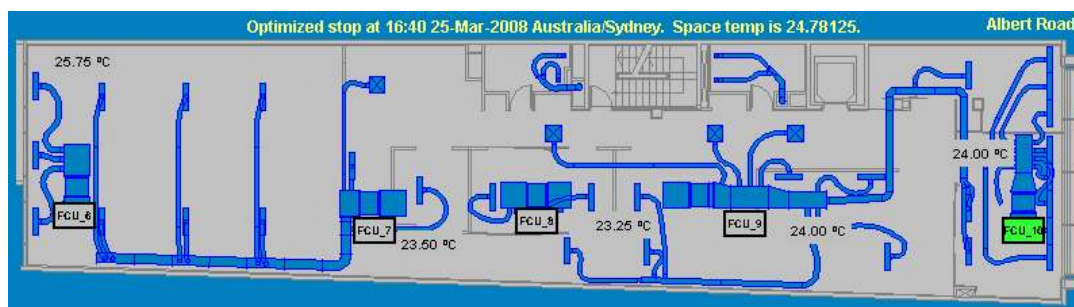
3.3.1 Redefined Optimum Start

On 18th July 2007, Alerton completed a range of works at the request of ECS to improve the operation of the building management system. Throughout winter, particularly on levels 2 and 4 we had been experiencing problems with the lack of heating in open plan areas. Interrogation of the BMS control programming indicated that these areas were being overlooked because the method of calculating the building floor temperature in order to satisfy the optimum start program was biased towards particular temperature sensing locations on each floor. Consequently, once a weighted average across the floor was reached, optimum start was satisfied.

This weighted average was altered to accommodate for the tendency of the open plan areas to take longer to warm up in the mornings.

The following figure 3.1 indicates the layout of the HVAC zones on level 2 at 40 Albert Rd. Each zone is fitted with a single temperature sensor.

Figure 3.1: Level 2 Layout



FCU6 is located in an open plan area, the remainder of FCU7 to FCU10 are located within predominantly partitioned spaces. A simple averaged temperature across the floor applies equal weighting to each zone, however the requirements of each zone are not equal. During winter months the consequence is that the open plan zone which takes longer to warm up in the mornings fails to reach the set point of 19 degrees Celsius by 8 am. The programming was changed to apportion greater weighting to the open plan zone, consequently the optimised start requirements are similarly weighted towards satisfying the temperature requirements of this zone. The improvement in occupant comfort levels was immediate.

There has been no identifiable change in the consumption of energy based on this alteration. Logic suggests that the energy consumption might increase slightly, however ultimately the optimum start system is still working to achieve a weighted averaged floor temperature of 19 degrees Celsius by 8am. The software change simply modifies the way this calculation is performed. Consequently the increase in heat flow into the zone FCU6 is compensated by a slight reduction into each of the zones FCU7 through FCU10.

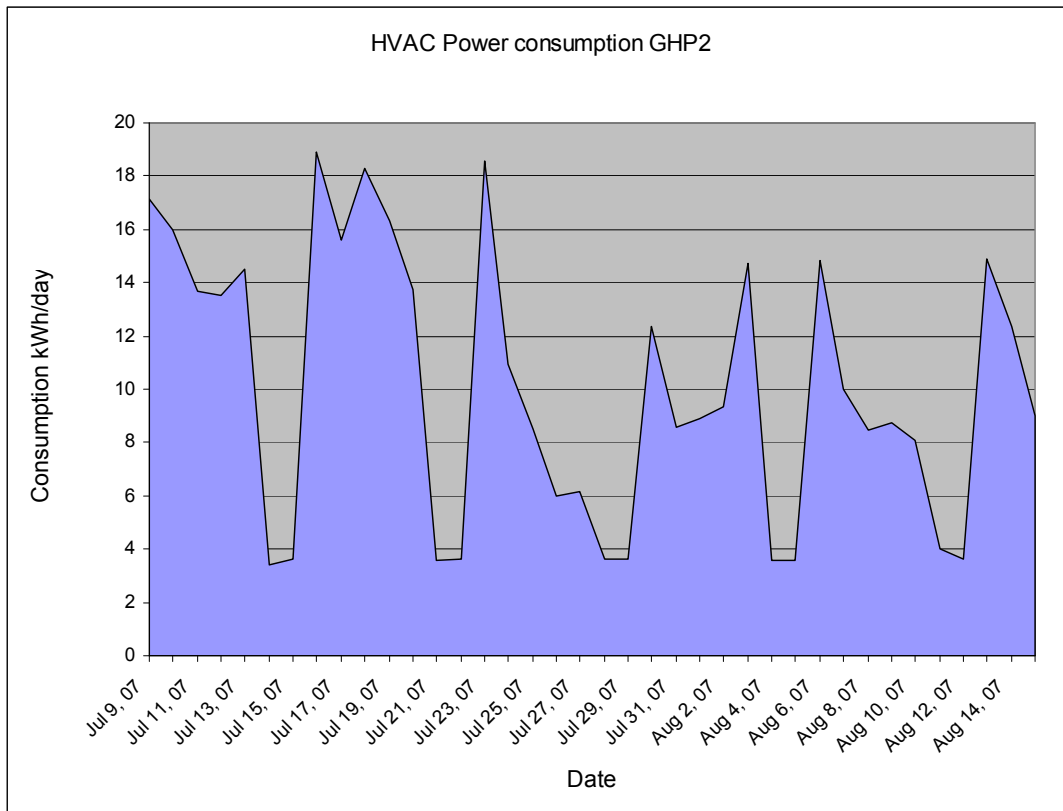
3.3.2 Exhaust damper and FCU linked operation

An erroneous operating condition was discovered within the first few weeks of winter when the building temperature continuously failed to achieve set temperature. During this time it was noticed that the stairwell area was quite warm and this led to the discovery that the stairwell dampers had been driven open by the BMS. Investigation of the control philosophy for the stairwell dampers followed and it was discovered that the error was in programming. The controlling function causing the BMS to signal the stairwell dampers to open was the FCU units, consequently whenever any FCU unit was operational the dampers opened and in this case allowed the heating air to escape into the stairwell.

The programming was amended on 18th July 2007 to correct the operation. The stairwell dampers are now limited to operation either in conjunction with the windows during night cool operation or in free cooling mode when the outside temperature is suitable for providing space cooling during the day. At all times, the fire system assumes full control over the damper positioning in the event of fire.

The impact is an immediate reduction in the consumption of both electricity and gas delivering space heating for levels 2, 3 and 4. Graph 3.1 indicates the metered power consumption for the HVAC plant at the time this modification was made. The software change was created on the 18th July and uploaded into the BMS system on the 23rd July 2007. Averaged daily consumption before this date can be seen at approximately 15 kWh/day while after the modification the figure is 9 kWh/day.

Graph 3.1: HVAC Power Consumption



3.3.3 FCU operation on night cooling mode

A further erroneous mode of operation was identified earlier in the year where the FCU units were operating during the night cool mode. This was rectified on 15th April 2007. The impact of this change is less pronounced as at this time of the year the HVAC consumption is typically low and sporadic depending on the variable weather.

3.3.4 Meeting room ventilation

Also on the 15th April 2007, a modification was made to the ventilation from meeting rooms which had been running at any time occupancy was detected anywhere on the level. This was rectified to deliver a ventilation run signal only when occupancy was detected in the meeting rooms.

3.3.5 Deletion of ventilation fan timed run signal

A secondary exhaust fan was identified as surplus to requirement and its run signal has been deleted from the BMS programming to eliminate the energy consumption of the unit. This was completed on 8th January 2007.

3.3.6 Time schedule changes for car park exhaust

Prior to the completion of modifications to the controls of the car park exhaust fan another simpler modification was made, allowing access into the time control scheduling to reduce the number of hours of operation of the car park exhaust fan. This was followed shortly afterward by the modification to run the fan by CO sensor control rather than timed control.

3.3.7 Windows override control

Manual control of the windows has been added in order to allow for the closing of windows when it is desired. Such occasions include when it is too windy or raining and the weather station has not yet signalled the condition to the BMS or it is too noisy outside. The performance of the all in one weather station in detecting rain has been poor and it is recommended that the building is fitted with equipment specific to the single purpose of rain detection and the control systems recommissioned accordingly such that rain detection is more reliable and the requirement for manual closure of windows reduced. This is further detailed in the recommendation section 3.5.

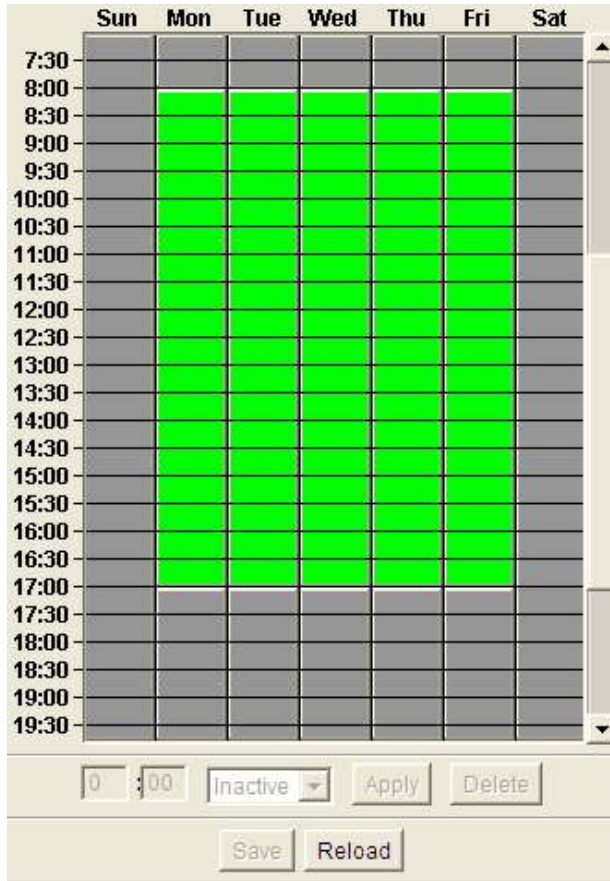
3.4 SECOND YEAR BUILDING MANAGEMENT SYSTEM PERFORMANCE

3.4.1 Normal Operation Mode

The BMS incorporates a clock and calendar which is programmed with the periods of normal (automatic) operation. The schedule for each floor has been modified to reflect building occupancy hours at which a minimum of 20% of staff are typically on site. In the case of Level 3 as indicated in figure 3.2, the schedule of operation has been reduced by two hours per day compared with the previous year.

On office levels the normal mode enables the plant for automatic operation. Occupancy detectors determine whether the plant will start in normal mode.

Figure 3.2: Level 3 Weekly Time Schedule



3.4.2 After Hours Operation

Air conditioning on each office floor is enabled via an individual time schedule with the provision for an after hours security card reader override. If staff need after-hours service, they are required to swipe their access card at the stairwell entry point to the floor. The duration of the after hours override is to be individually adjustable for each floor. This is currently set at two hours.

Swipe logs and FCU mode records indicate that the after hours operation of air conditioning is not being used on any level of the building. It is likely that some staff may not be aware of the availability of after hours service.

3.4.3 Optimum Start / Stop

Optimum start and stop control uses past performance data as well as internal and external temperatures to determine the following:

- The latest time that the plant is required to start in the morning in order to bring internal zone temperatures to within set point levels by the beginning of the time schedule
- The earliest time that the plant may be stopped in the afternoon in order to maintain the internal zone temperatures within set point levels for the remainder of the time schedule.

Figure 3.3: Optimum start / stop for Level 2

7:50:06 8-Oct-2007 Australia/Melbourne	Optimized start at 7:50 8-Oct-2007 Australia/Sydney. Space temp is 18.65625.
16:40:08 8-Oct-2007 Australia/Melbourne	Optimized stop at 16:40 8-Oct-2007 Australia/Sydney. Space temp is 21.96875.
7:59:10 9-Oct-2007 Australia/Melbourne	Optimized start at 7:59 9-Oct-2007 Australia/Sydney. Space temp is 18.9375.
16:40:12 9-Oct-2007 Australia/Melbourne	Optimized stop at 16:40 9-Oct-2007 Australia/Sydney. Space temp is 22.875.
16:40:16 10-Oct-2007 Australia/Melbourne	Optimized stop at 16:40 10-Oct-2007 Australia/Sydney. Space temp is 22.90625.

Figure 3.3 above clearly identifies the value of optimum start and stop control, the BMS system analyses the indoor environment and compares this with outdoor temperature, and its history of operation to calculate the minimum energy required to satisfy the start and stop goals. For level 2 in early October 2007, figure 3.3 shows air conditioning commenced its morning operation shortly before 8:00 am on the 8th and 9th October. On the 10th October the optimised start was not required as the space had naturally achieved set point. In the evenings the air conditioning was consistently shut down at 16:40 pm.

Level 4 continues to experience lower internal temperatures overnight compared to the other levels due to its exposure and thus requires an optimum start on most days during winter. Rectification of some programming errors has improved the performance of the HVAC plant and consequently reduced the duration of optimum start in winter, see section 3.3.2.

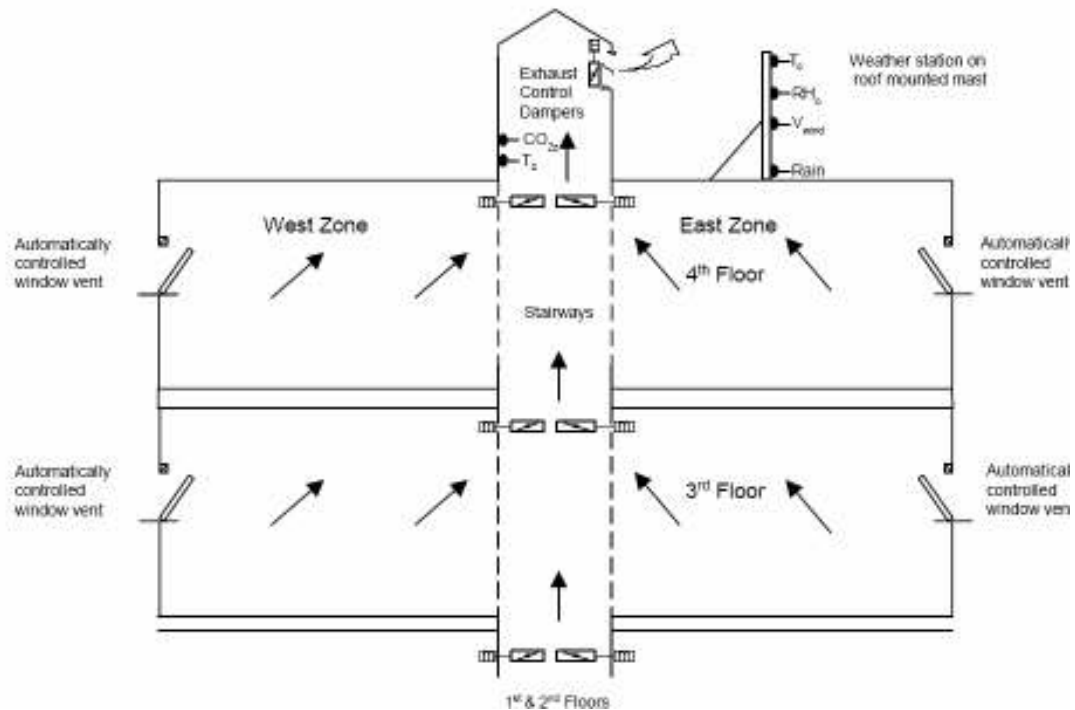
3.4.4 Natural Ventilation

The building utilises a combination of natural and mechanical ventilation (i.e. a mixed mode system). Automatic controls are applied to the main ventilation inlets (windows) and outlets (wall mounted exhaust dampers in fire stairways) in order to maintain acceptable space temperature and carbon dioxide concentration. The operation of the windows is proportionally controlled over a temperature range and is slowly adjusted to avoid distracting occupants.

The building relies on the stack effect or thermal buoyancy and clear air pathways for natural ventilation to work satisfactorily. The difference between indoor and outdoor temperature causes a pressure difference that affects air movement in the building. Whenever indoor air is warmer than outdoor air, the building can draw in

air through the windows and expel air at the top of the stairways. The basic operation is illustrated in figure 3.4 below.

Figure 3.4: Natural Ventilation at 40 Albert Road



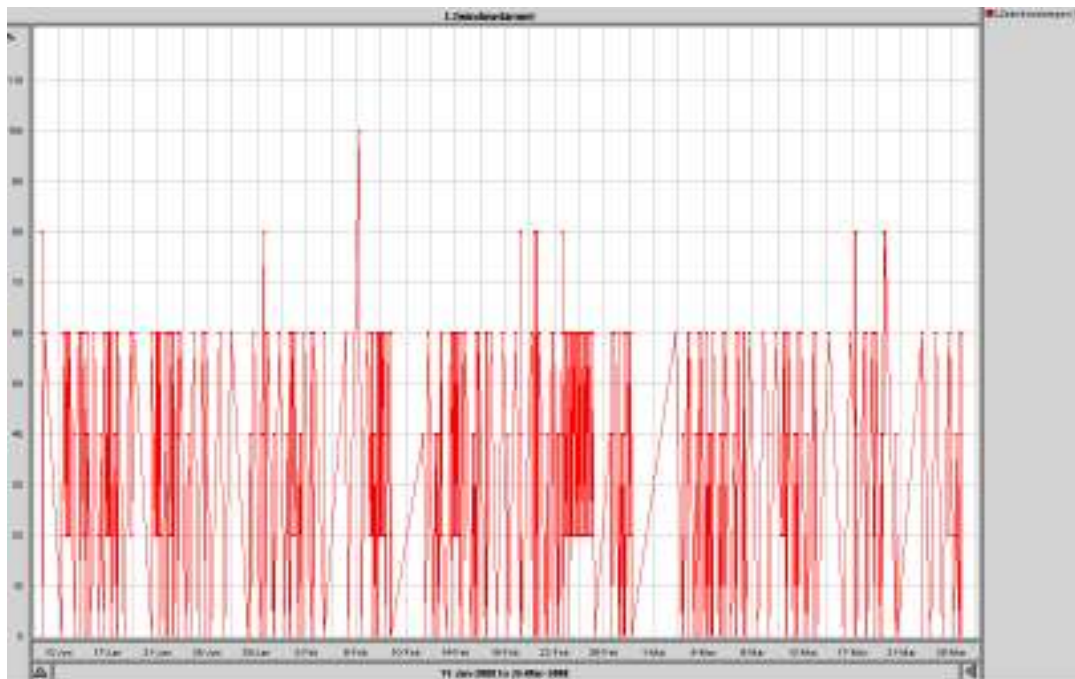
A number of programming errors were identified with the natural ventilation operation, in particular with the linking of exhaust ventilation and FCU operation, which resulted in the plant operating at raised consumption levels and the conditioned air was being lost through the exhaust dampers. The various modifications to the BMS system as detailed in section 3.3 has rectified these issues.

There continues to be some concern over the accuracy of the weather station rain and wind speed sensor. These items were calibrated and recommissioned in line with recommendations in the First Year Building Report, however, they appear still to be failing on occasion. This has led to the recommendation this year to install dedicated equipment for the sole performance of rain detection and perhaps also wind speed.

3.4.5 Night Cooling

Night cooling involves opening east and west louvered windows after-hours in order to flush warm air out of the building. This function was designed to bring internal space temperatures down to the floor set-points before the start of the next day’s time schedule (and optimum start time), avoiding the need to cool the space using the chillers.

Figure 3.5: Night cooling window damper positioning



Night cooling is operating almost daily in recent months and generally across the warmer months of the year. Figure 3.5 indicates the window damper positioning for level 2 windows over the past three months with a high level of free night cooling. The figure displays damper position in red operating at various damper positions although predominantly open 80%. On occasion when the night time temperature is high, the BMS ensures window dampers remain closed. There are a number of days within the data which indicate this was the case, particularly at the beginning of March.

3.5 RECOMMENDATIONS FOR FURTHER TUNING

3.5.1 Installation of dedicated rain detection

The performance of the all in one Viasala weather station in detecting rain has been poor and it is recommended that the building is fitted with equipment specific to the single purpose of rain detection and the control systems recommissioned accordingly such that rain detection is more reliable and the requirement for manual closure of windows reduced.

Table 3.4 summarises the recommendation for installation of dedicated rain detection.

Table 3.4 Installation Recommendation – Dedicated rain detection

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments
Installation of dedicated rain detection	\$700	\$0	0	N/A	This measure is designed to improve the indoor environment for occupants

3.5.2 New solar hot water circulation pump and controls upgrade

Alterations are planned for the existing solar hot water system on the roof top, with the supply and installation of a new solar circulation pump, temperature differential controller and flow control valve. The works will cost approximately \$3,500 and are expected to significantly increase the reliability on the solar hot water collector system and consequently reduce the reliance on gas hot water heating.

Table 3.5 summarises the recommendation for solar hot water upgrades.

Table 3.5 Installation Recommendation – Solar Circulation Pump and Upgrades

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments
Installation of new solar hot water circulation pump and upgrade of the system controls	\$3,500	\$650	4.5	5.38	This measure is expected to significantly increase reliability in the hot water systems and maximise the solar heat contribution

CHAPTER FOUR | LIGHTING & LIGHTING CONTROLS

This chapter evaluates the performance of the Lighting and Lighting Controls, an ECS installed control system which senses for human occupancy and manages the delivery of lighting, heating, cooling, fresh air and security services accordingly. The Lighting and Lighting Control system has remained mostly unchanged from the original design although a few minor improvements have assisted to provide energy savings.

4.1 LIGHTING & LIGHTING CONTROLS SUMMARY

There are often a number of minor opportunities identified during the course of the year and in many cases the implementation of such works is done immediately. There are no major upgrades recommended for the lighting & lighting control systems although table 4.1 displays a number of minor works currently in progress.

Table 4.1: Recommendations for performance improvement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Replacement of incandescent lighting in showers with compact fluorescent	\$10	\$2.46	.0001	4.06	Figures are dependant on approximate staff usage through out the year
Car park microwave detectors modification	\$0	\$9.30	0.54	instantaneous	To combat false triggering of specific occurrences
Occupancy sensor masking	\$80	\$2.10	0.025	38	This recommendation addresses nuisance triggering of the enclosed office lighting for both occupant satisfaction and energy reduction purposes.

4.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

There have been a few changes to the lighting and lighting controls over the past year which have delivered nominal savings. The lighting and lighting controls are a fundamental business unit for ECS and consequently the original installed performance was already of very high standard. Subsequent changes in the second year have delivered minor improvements to the efficient operation of the building. The following table 4.2 indicates the first year recommendations for the lighting and lighting control systems.

Table 4.2: Table of all first year lighting & lighting control recommendations

Recommendation	Capital Cost	Annual \$ Saving	Actual CO2 Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Replace halogen down lights with compact fluorescent	\$1700	\$140	1.34	8.93		Implemented See 4.2.1
MLS control of DSI ballasts	\$4183	\$531	7.172	7.175		Implemented See 4.2.2
Lift lighting controls	\$1733	100.09	1.02	17.317	This energy saving recommendation also included in lift section	Implemented See 4.2.3
Closing office doors	\$0	negligible	negligible	negligible	Staff have taken it upon themselves to ensure doors are closed when offices not occupied	Implemented See 4.2.4
Reducing the detector 'switch off' delay	\$0	\$2.40	0.043	Immediate	Figures based on building vacancy	Implemented See 4.2.5

4.2.1 Replacement of halogen down lights with compact fluorescent

It was recommended that halogen down-light fittings to be replaced with compact fluorescent fittings throughout the building. The areas of concern for this recommendation were the lift, where the emergency lamps are fed directly from the lift lighting controller at 12V, the level 3 boardroom and the reception/foyer area on ground floor.

Level 3 Boardroom halogen lamps were replaced with 11W Megaman compact fluorescent lamps. They have a 68% reduction in energy consumption from the existing 35W halogen lamps while still outputting the same lumens / m².

Two halogen down lights in the lift were replaced with 2 x 11W Megaman lamps due to them being feed by a direct 240V supply. The other lamps were left with their 12V lift lighting controller connected to the emergency lighting circuits. One of the 35W halogen lamps was replaced with a 6W LED lamp as a trial of the new fitting.

The reduction in energy consumption from the old halogen lamp to the LED source is 83%.

Table 4.3 Results of Energy Control Measure – Replace halogen down lights

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO2 Reduction	Actual tCO2 Reduction
Replace halogen down lights with compact fluorescent	25 th February 2007	\$140	\$140	1.34	1.34

While the individual performance improvement for each lamp is known, the savings calculation requires that the 'ON' time for each lamp is known. Currently we have no means of identifying the run time for individual lamps. In the particular case of the lift, metering data is available for this circuit which offers the ability to produce a savings analysis throughout the second year. This information is provided in section 4.2.3 below and incorporates two energy saving measures, lamp replacement and sensor control.

4.2.2 MLS control of DSI ballasts

The “Standing losses” of DSI ballasts during the first year of building operation equated to approximately 250 W per floor for each level of the building. It was recommended that the MLS be extended on each floor to switch off these circuits when the building is vacant. A UBT2000 Universal Bus Transceiver was installed on each level to switch contactors controlling the lighting circuits of each floor to reduce this ballast standing loss. The calculated saving is approximately 5 MWh per year.

Table 4.4 Results of Energy Control Measure – MLS control of DSI ballasts

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO ₂ Reduction	Actual tCO ₂ Reduction
MLS control of DSI ballasts	3 rd / 4 th January 2007	\$624	\$531	7.62	7.175

4.2.3 Lift lighting controls

During the first year building operation the lift lighting remained on for 24 hours a day, 7 days a week. It was recommended to install an occupancy sensor within the lift to switch the lights on only when the lift is occupied. A PIR (Passive Infra Red) MLS occupancy sensor was installed with a time delay of 1 minute to limit the on time of the luminaries to a minimum. Utilising our meter monitoring website “intermoco,” comparing the lift usage in energy before and after installation has shown a decrease of 756 kWh. This represents a 24.8% reduction in annual consumption and a drop of 1.02 tCO₂ carbon emissions from the combination of occupancy and re-lamping of halogen down lights.

Table 4.5 Results of Energy Control Measure – Lift lighting controls

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO ₂ Reduction	Actual tCO ₂ Reduction
Lift lighting controls	1 st March 2007	\$72	\$100	0.88	1.02

4.2.4 Closing office doors

The installed occupancy sensors have a detection window of 360° with an approximate detection range of 6 meters in diameter. Nuisance switching had been occurring in enclosed offices when passing movement triggers the sensor and switches lights on in an unoccupied room. The staff at 40 Albert Road has taken it upon themselves to ensure that when an office is vacant, its doors remain closed to reduce of false triggering.

Table 4.6 Results of Energy Control Measure – Closing office doors

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO2 Reduction	Actual tCO2 Reduction
Closing office doors	2007-2008	negligible	negligible	negligible	negligible

Savings were difficult to measure due to the subjectivity and difficulty in assessing when the lights will be on or off and which of those times are nuisance triggering events as opposed to actual occupancy, a crude assessment has been made and indicates savings of perhaps 17 kWh per annum.

This energy control measure is non-testable and often unreliable. However, on occasion when it is done it is effective in stopping the detectors from triggering. An alternative solution to modify the detection range by occupancy sensor masking for the relevant sensors has been added to the second year recommendations. The consumption through nuisance switching is unknown although understood to be low. Further details provided in recommendation 5.4.3.

4.2.5 Reducing the detector 'switch off' delay

It was recommended that the time setting for the common zones / building zones be reduced to 10 minutes across all levels. This adjustment was easily made through the hand held programmer, and by reducing the time setting by 5 minutes gives an approximate saving of 30 kWh over the last year.

Table 4.7 Results of Energy Control Measure – Reducing the detector 'switch off' delay

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO2 Reduction	Actual tCO2 Reduction
Reducing the detector 'switch off' delay	3 rd February 2007	\$2.40	\$2	0.043	0.036

4.3 SECOND YEAR LIGHTING & LIGHTING CONTROLS CHANGES

4.3.1 Zone address changes

The east stairwell between ground and basement level was identified as addressed to the same zone address as reception, consequently lighting was switched 'on' based on reception occupancy. This was changed to give it its own individual address where it now saves approximately 6 hours a day on lighting. This equates to approximately 7 kWh a year.

4.4 SECOND YEAR LIGHTING & LIGHTING CONTROLS PERFORMANCE

This section of the report analyses the actual performance of both the lighting system and the lighting control system in the second year of operation. The second year data is compared to both the first year performance and initial design specification.

4.4.1 Lighting Performance

Table 4.8 summarises the building lighting levels measured across the lighting installation as it exists currently and also in comparison to first year measurements and the original design intent for the building.

Table 4.8: Building lighting levels

	% of Total NLA	W/m2/100Lux	Ave Maintained Luminance*
Base Building (Design intent)	97%	1.39	326.61
Tenancy (Uncontrolled lighting)	97%	1.42	331.23
First year performance (Controlled lighting)	97%	1.66	305.55
Second year performance (Controlled lighting)	97%	1.61	305.55

* Average light level across floors 1-4

In order to achieve the full Green Star points the lighting installation should achieve a lighting density target of 1.5 W/m²/100Lux or lower. The operation data indicates that the building is performing at 1.61 W/m²/100Lux and consequently under this item the building would achieve only 3 out of the 4 points.

It is worth noting that in some buildings with an installed lighting density less than 1.5 W/m²/100Lux, building occupants complain lighting level is too low. Uncontrolled task lighting is installed and the danger is that this task lighting remains ON to boost the base lighting regardless of occupancy. At 40 Albert Rd we have endeavored to reduce W/m²/100Lux as far as possible without compromising occupant satisfaction and without the installation of further task lighting.

The installed lighting load has increased from the base building and tenancy design due to the tenancy layout introducing inefficiencies in the lighting design. These are caused by the following:

- The unavoidable addition of offices and internal walls requiring additional light fittings to meet Standards,
- The introduction of additional display lighting within the floors to illuminate company signage
- The addition of halogen sources on the ground, level 1 and level 3

While re-lamping 35W halogen down lights to 11W Megaman compact fluorescents has produced some energy savings and reduction in luminance, the majority of re-lamping occurred in areas of the building not included within the NLA, such as the lift and reception foyer.

The lighting electrical demand for the building is shown in table 4.9 for the base building design, the tenancy fit-out design and the actual, metered demand (controlled by the MLS) for first and second year performance.

Table 4.9: Building lighting electrical demand

	Maximum demand	% Improvement over Design
Base Building (Design intent)	6.27 kW *	
Tenancy (Uncontrolled lighting)	10.53 kW	
First year performance (Controlled lighting)	6.71 kW	24.5% reduction
Second year performance (Controlled lighting)	6.519 kW	31.8% reduction

* Does not include car park lighting

The installed tenancy lighting loads had increased the maximum design demand beyond the design intention due to the range of factors discussed above. However, the lighting control system has produced a reduction in

total lighting demand through the benefits of occupancy control. The performance of the lighting control system is analysed in the following section 4.4.2.

4.4.2 Lighting Controls Performance

Lighting performance from design through to current consumption is tabulated in table 4.10 below. The effect of the lighting controls on the energy performance of the building lighting is a 24.5% saving for first year consumption and a 31.8% saving for second year consumption measured against the same lighting fittings in uncontrolled mode.

Table 4.10: Annual lighting electrical consumption

	Annual consumption	Expressed as a percentage variance from design intent
Tenancy Design (uncontrolled)	32,853 kWh**	N/A
Pre-installation ABGR report consumption estimation*	36,000 kWh	9.58% higher consumption
First year performance (Controlled)	24,793 kWh	24.53% lower consumption
Second year performance (Controlled)	22,411 kWh	31.78% lower consumption

* Source: 40 Albert Road ABGR & Energy Report, 8th March 2005

** Estimated uncontrolled lighting hours = 3,120 per annum

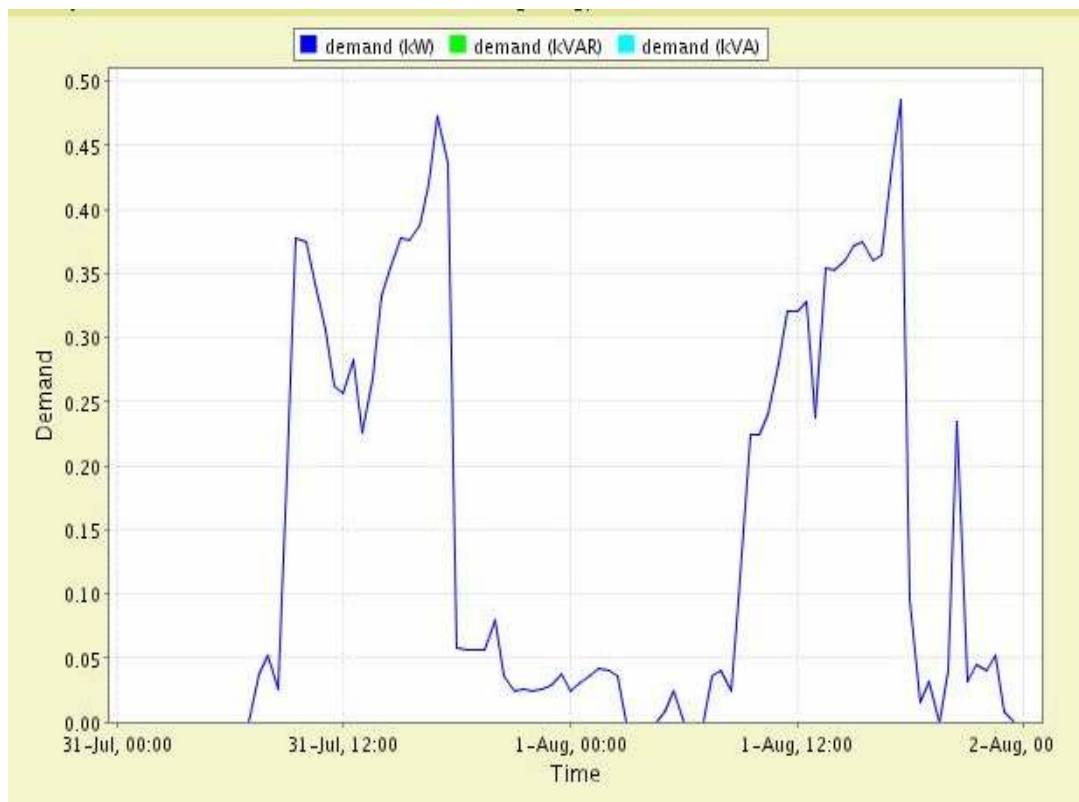
The lighting control system delivers savings beyond all the pre-installation predictions. The second year figures indicate an improvement over the first year case, this is the result of a number of energy saving measures identified and implemented through the first year building report.

Lighting controls deliver savings through the following types of control which the system provides:

- Occupancy switching
- Photocell regulation

It is not possible to separate the savings between these two forms of control because both forms impact upon the lighting electrical demand concurrently and to a varying degree throughout the day. Photocell regulation provides demand reduction and energy savings during the daytime by capitalising on natural light ingress through dimming of lighting fixtures in regions close to natural light sources. Figure 4.1 indicates the daily load profile for two consecutive days, July 31st 2007 and August 1st 2007. The demand reduction by photocell regulation is indicated by the dip on the curve for July 31st 2007. Figure 4.1 also identifies demand variability throughout the day based on occupancy sensing resulting in the switching of lighting ON and OFF as staff move in and out of office spaces. In uncontrolled mode we would expect this to show a box curve at the full demand for the full period of office hours.

Figure 4.1: Level three office lighting demand July 31st and Aug 1st 2007



Photocell regulation

Photocell regulation provides considerable dimming of occupied zones on the east side of the building in the morning and on the west in the afternoon. Dimming during sunny periods is to a level as low as 3%, while maximum levels across the building (during times of little ingress natural light) are around 85% of full lamp output. The maintained light levels were set at night-time during commissioning of the building to ensure that the maximum levels were not exceeding the required lux levels. As lamp output depreciates, it is expected that this 85% maximum level will increase in order to maintain these required levels. This may increase energy consumption very slightly.

Occupancy control

Occupancy control is performed by each MLS sensor by switching lighting off when the area is vacant. For every motion triggered, an internal time delay is reset within the sensor. Once this time delay has expired without any motion sensed the lights are switched off.

Standard group zones throughout the building, which consist of enclosed offices and open plan office area are set to a time delay of 5 minutes. Common zones such as corridors and stairwells are currently set to 10 minutes. Areas such as utility rooms and kitchens are set to shorter time delays, between 1 and 5 minutes. Car park lighting is set to 5 minutes.

Occupancy control is working effectively throughout the building, ensuring lights are switched off when an area is vacant, leading to considerable energy savings and better-than-expected performance. The bonus result delivered by the occupancy control is the following:

- The savings delivered by switching off air-conditioning zones based on occupancy, which are far more considerable than even the lighting control savings
- The added function of interfacing to the security system to provide building wide occupancy status

The installed lighting control system has been commissioned with luminaires being grouped together via the MLS to form lighting control zones. The number of lighting zones varies on each level and each floor has been programmed based on the tenancy layout as can be seen in the following table.

Table 4.11: Second year lighting control data

Level	NLA [m2]	% of Total NLA	No. of Zones	Average Zone Size [m2]
Level 1	304.4	25	12	25.36
Level 2	303.7	25	23	13.20
Level 3	303.6	25	17	17.85
Level 4	264.7	22	12	22.06
Sub Total	1,176.4	97		
Basement	0	0	1	N/A
Ground	38.6	3	6	6.43
Total	1,215.0	100		

As can be seen from the table, for 97% of the NLA the lighting control zones do not exceed 100m², thus meeting the design criteria.

The switch off delay of the MLS detectors has been commissioned with the following time settings:

- Common Zones / Building Zones : 10 minutes
- Offices / Meeting Rooms / Open plan areas / Stores: 5 minutes

One of the major issues regarding the lighting power consumption was ballast losses. This issue was addressed by the installation of an number of contactors controlled by UBT's on each level. This allows the ballasts to be switched off when the building is vacant and come back on when the first person arrives in the morning.

The re-lamping of the halogen down lights has also made a positive impact on the emery consumed. A simple procedure of replacing 35W halogen lamps to 11W Megaman has improved the W/m2/100LUX and producing energy savings.

4.5 RECOMMENDATIONS FOR FURTHER TUNING

4.5.1 Incandescent lamp replacement

At present the lighting within the showers is provided by an incandescent lamp. Incandescent lamps are inefficient and have low life spans. It is recommended that the incandescent lamps installed within the showers are replaced with integral compact fluorescent lamps of equivalent wattage.

Table 4.12: Recommendations for performance improvement – incandescent lamp replacement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Replacement of incandescent lighting in showers with compact fluorescent	\$10	\$2.46	.0001	4.06	Figures are dependant on approximate staff usage through out the year

4.5.2 Modifications to car park microwave detectors

It has been noticed that the microwave detectors in the basement and ground carpark sometimes falsely trigger according to specific situations. On windy days, both garage doors shake and therefore cause the lights to activate when no one has occupied the space. Furthermore, on rainy days, water droplets on the ground carpark from the vented louvers also sometimes cause the microwave detectors to see movement. These detectors are connected to the managed lighting system (MLS), and once triggered set of all the lights in building zones which include reception, foyer and stairs as well. Taking these microwave detectors off the managed lighting system and making the carparks work independently would stop the building zones from triggering falsely.

Table 4.13 Recommendations for performance improvement – car park detector modification

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments
Car park microwave detectors modification	\$0	\$9.30	0.54	instantaneous	To combat false triggering of specific occurrences

4.5.3 Occupancy sensor masking

The installed occupancy sensors have a detection window of 360° with an approximate detection range of approximately 6 metres in diameter. Within open plan areas, stores and large meeting rooms this detection area does not pose a problem, however within enclosed offices, when unoccupied, passing movement triggers the sensor as most offices are smaller than the detection range. It is recommended that when offices are vacant or left for a period of time that the doors are closed to prevent miscellaneous triggering of lighting.

Masking of detectors, similar to what has been undertaken on the level 4 kitchen, in appropriate areas such as level 2 and 3 kitchen and task lighting on level 2 to reduce the detection range is recommended and thus reduce the amount of nuisance triggering of detectors.

Table 4.14 Recommendations for performance improvement – car park detector modification

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments
Occupancy sensor masking	\$80	\$2.10	0.025	38	This recommendation addresses nuisance triggering of the enclosed office lighting for both occupant satisfaction and energy reduction purposes.

CHAPTER FIVE | ON-SITE GENERATION

This chapter analyses the performance of the various on-site renewable energy generation components installed within the Szencorp building.

Recommendations for improving the current performance of the on-site generation components are outlined in table 5.1. None of the recommendations from the first year building report has been fully implemented although two of the three recommendations are under investigation. A number of changes to the on-site generation equipment have occurred within the last 12 months. These changes are summarised in section 5.3.

5.1 ON-SITE GENERATION SUMMARY

Table 5.1: Recommendations for performance Improvement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comment
Modify mounting of existing polycrystalline PV array in order to overcome self – shading problem.	\$5,000	\$ 265	2.9	18.8	This issue was raised in the first year building report, please refer to Appendix A for full description.
Install similar PV arrays as that currently installed over Level 4 windows, to the remaining western windows.	\$105,000	\$ 795	8.8	132	Obviously this would not be considered on payback period alone. It would however serve the dual purpose of solar shading for the western windows, as well as increase the renewable energy generation capacity of the building by approximately 6 MWh/year.
Regular ongoing monitoring and maintenance of all onsite generation systems to ensure optimum output, and prompt identification of any system faults	TBC*				This will help ensure that issues such as the solar pergola breakdown are identified and remedied as early as possible.

*A proposal for ongoing monitoring is to be issued in conjunction with the submission of this report.

5.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

Table 5.2 below provides a record of all of the identified on-site generation system recommendations from the first year building report. For full details of the basis of these recommendations the full text of the first year building report is provided in Appendix A.

Table 5.2: Table of all first year on-site generation recommendations

Recommendation	Capital Cost	Annual \$ Saving	Actual CO2 Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Modify mounting of existing polycrystalline PV array in order to overcome self-shading problem, as well as to optimise panel orientation and tilt angle	Unknown	Unknown	Unknown	Unknown	This issue was under investigation by BP Solar and Origin Energy	Not Implemented
Investigate feasibility of installing a sun-tracking parabolic PV array	\$36,000	\$1,440	17.6	25		Investigation completed See 5.2.1
Monitor wind data in order to determine feasibility of installing a wind turbine					Onsite wind data for at least 12 months is required to determine feasibility and size of turbine required	See section 5.5 for full detail

5.2.1 Wind turbine feasibility

At this stage the recommendation for installation of a wind turbine is under investigation. Metering data has been extracted from the BMS system and this has formed the basis of some preliminary engineering design calculations. Since the first year recommendation is still under investigation the details of this recommendation have been reported in an added section 5.5 for ongoing investigations.

5.3 SECOND YEAR ON-SITE GENERATION CHANGES

Changes made to the on-site generation systems over the last 12 months include:

5.3.1 Installation of western facing solar shade PV array on level 4 windows

A 1.65 kWp polycrystalline PV array was installed over the western facing level 4 windows in January 2008. The electrical output of this array is fed through it's own dedicated grid-connect inverter to the main building switchboard. As detailed in section 5.4.2, this solar PV system has increased the expected on-site electrical generation capacity of the building by approximately 2 MWh per annum. The additional benefit of the array is to provide shading to the western facing level 4 windows. This shading will help reduce the cooling load required during summer periods to this area, as well as reducing glare to improve the working environment of the western end level 4 building occupants. See section 5.4.2 for the performance of this installation.

5.3.2 De-commissioning of fuel cell unit

The fuel cell unit was shut down on the 8th August 2007, and has been in hibernation mode since. It has not been generating any energy since this time. It is expected that this unit will be de-commissioned later this year.

5.3.3 Repairs to solar pergola DC isolating switch and inverter

The solar pergola array was non-operational for a period of 86 days throughout the period of October 2007, through to January 2008. This was due to water ingress of the conduit work associated with the DC control system components. This problem was remedied in early January 2008, and the system is now fully operational once again. It is expected that identification of these issues would improve in line with improvements to the metering and monitoring system. While this particular circuit is metered, issues as discussed within the metering section of the report have resulted in a lack of confidence in the displayed data.

5.4 SECOND YEAR ON-SITE GENERATION PERFORMANCE

The on-site energy generation systems currently installed within the Szencorp building are:

- A BP Solar 4.8 kWp Fixed Polycrystalline Solar Photovoltaic Array
- A RWE Schott Solar 1.1 kWp Fixed Amorphous Solar Photovoltaic Array
- A BP Solar 1.65 kWp Fixed Polycrystalline Solar Photovoltaic Array
- A Ceramic Fuel Cells Ltd 1 kWp Micro Combined Heat and Power Solid Oxide Fuel Cell

All of the electrical energy generated by these various sources is fed into the main switchboard via grid-connect inverters. This generated electrical energy is utilised on-site to help meet the electrical demand of the building, as well as being able to be exported back to the network electrical grid during periods of low demand.

This section will analyse the second year performance of each system, and identify reasons for any differences between actual and predicted performance. The time period used to analyse the performance of each system is the 12 month period from 1st March 2007 through to 1st March 2008.

Table 5.3: Second year on-site generation performance summary

Item	Operating to Specification	System requires rectification	Improvements Recommended
5.4.1 Polycrystalline PV array – Rooftop	✘	✓	✓
5.4.2 Polycrystalline PV array – Solar Shades	✓		
5.4.3 Amorphous PV array – Solar Pergola	✓		
5.4.4 Ceramic Fuel Cell	n/a	n/a	n/a

5.4.1 Polycrystalline PV array – Rooftop

Predicted Performance

The predicted system generation capacity was calculated based on the assumptions listed in the first year building report. The total annual energy contribution due to this Solar PV array was predicted to be 5.9 MWh. Using the assumption that the system was operational 365 days per year, then we have:

$$\begin{aligned} \text{Predicted Average Daily Generation} &= 5.9 \text{ MWh} / 365 \text{ days} \\ &= 16.16 \text{ kWh/day} \end{aligned}$$

Actual Performance

Electrical energy generated by the system is monitored through the buildings metering system. The array is split into two sub-arrays each feeding their generated power through a grid-connect inverter. One meter is installed on each inverter in order to monitor the power generated by the solar PV system.

The actual electrical energy generated during the analysis period is **5.08 MWh**.

$$\text{Actual Average Daily Generation} = 5.08 \text{ MWh} / 365 \text{ days}$$

= 13.94 kWh/day

Therefore, we can see that the difference between the predicted performance of the solar PV array is:

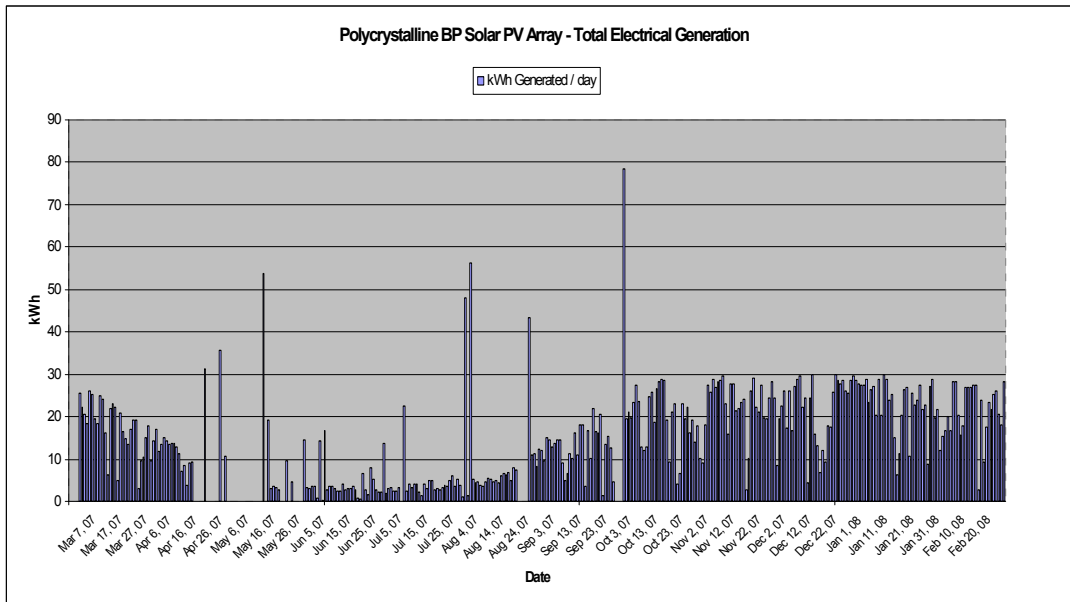
$$\begin{aligned}
 \text{Difference} &= \text{Actual performance} - \text{Predicted performance} \\
 &= 13.94 \text{ kWh/day} - 16.16 \text{ kWh/day} \\
 &= - 2.2 \text{ kWh/day}
 \end{aligned}$$

Table 5.4: Predicted vs. actual output performance

	Daily generation (kWh)	Annual generation (MWh)
Predicted Performance	16.16	5.90
Actual Performance	13.94	5.08
Difference	- 2.22	- 0.82
	- 13.7%	- 13.7%

At present, the polycrystalline solar array is not performing as well as what was predicted in the initial design specification.

Graph 5.1: Polycrystalline PV Electrical Energy Generation



As can be seen from figure 5.1 above, the winter performance of this array is very poor. Average electrical output for this array during the winter months (June, July, August) is under 6 kWh per day. The major factor affecting the output performance of this PV system, is the fact that there is a large amount of shading of the

panels present during the winter period due to the sun's much lower angle in the sky. This issue, as well as recommendations to alleviate the problem, are explained in further detail in the first year building report text.

The large 'spikes' in the graph are due to metering glitches, and not the result of a large amount of generation for that particular day. As can be from the graph above, for the days immediately preceding each 'spike' no data is shown. The data was still being recorded however, and so once the metering problem had been overcome, the total amount of generation recorded during the period was totalled and displayed all in the one day, thus producing a large 'spike' for that day.

Explanation/reasons for difference

The reasons for the difference between the predicted and actual performance of the polycrystalline solar array are the same as those listed in the 1st year building report, as the conditions have not changed. For a full description of the reasons, as well as the list of recommendations to alleviate the issues please refer to the 1st year building report found in Appendix A.

5.4.2 Polycrystalline PV array – Solar Shades

A 1.65 kWp Polycrystalline Photovoltaic Array has recently been installed (Jan 2008) on the western end of the building, above the 4th floor windows (see figure 5.2 right). This array consists of 10 x BP Solar 165 Watt panels, which feed their generated electrical energy into a newly installed grid connect inverter. The panels are installed at an angle of approx 30 to 35 degrees.

Image 5.2: Polycrystalline PV Solar Shades – Western End



As can be seen from figure 5.2, this array serves the dual purpose of on-site electricity generation, as well as providing shading to the west facing level 4 windows. This photo was taken on the 11th March 2008 at approximately 4:00pm, and shows that the shading aspect of this array is operating well. During the time of

day when the full western sun would normally be striking the windows, it can be seen that the entire windows are in complete shade as intended.

Predicted Performance

Due to the fact that this PV array is not orientated to face true north (which is the ideal situation for maximum solar PV generation), then the predicted electrical generation of this array would not be expected to reach its maximum potential. The total annual energy contribution due to this Solar PV array was predicted to be 2 MWh. Using the assumption that the system will be operational 365 days per year, then we have:

$$\begin{aligned} \text{Predicted Average Daily Generation} &= 2 \text{ MWh} / 365 \text{ days} \\ &= 5.5 \text{ kWh/day} \end{aligned}$$

Actual Performance

Electrical energy generated by the system is monitored through the buildings metering system. The data available for this however has only been online and available from 9th March 2008. Information on the total amount of energy generated by the array to date is also stored in the inverter. As this data allows for a larger sample size, it will be used in the analysis of the system performance, rather than the meter data.

The actual electrical energy generated by the array to date as stored in the inverter is **569.5 kWh** (Date of measurement 25th March 2008). The date of final completion of the array installation is 10th January 2008. This results in a sample size of 75 days.

$$\begin{aligned} \text{Actual Average Daily Generation} &= 569.5 \text{ kWh} / 75 \text{ days} \\ &= 7.59 \text{ kWh/day} \end{aligned}$$

Therefore, we can see that the difference between the predicted performance of the solar PV array is:

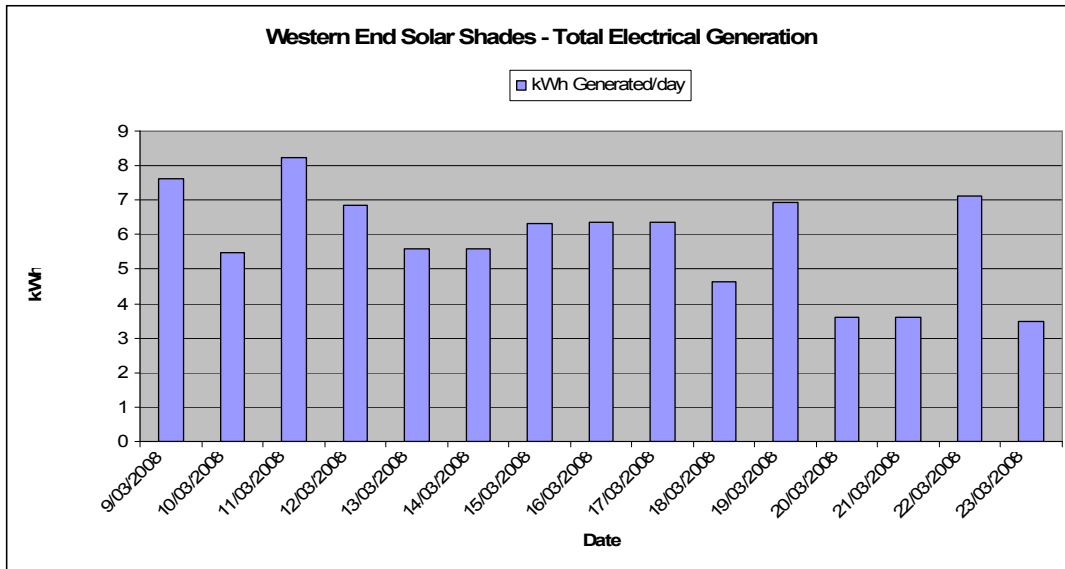
$$\begin{aligned} \text{Difference} &= \text{Actual performance} - \text{Predicted performance} \\ &= 7.59 \text{ kWh/day} - 5.5 \text{ kWh/day} \\ &= + 2.09 \text{ kWh/day} \end{aligned}$$

Table 5.5: Predicted vs. actual output performance

	Daily generation (kWh)	Annual generation (MWh)
Predicted Performance	5.5	2.0
Actual Performance	7.59	2.77
Difference	+ 2.09	+ 0.77
	+ 38 %	+ 38 %

Metering data for this array as previously mentioned has been available from the 9th March onwards, and is shown in figure 5.3 below.

Graph 5.2: Polycrystalline PV Solar Shades – Western End



This array appears to be operating quite well, however this generation data is only depicting the summer performance of the system. It would be expected that the winter electrical generation of this system would be quite low due to its west facing orientation. In winter, the reduced number of sunlight hours will result in far less solar radiation actually striking this array, and thus reducing the expected electrical output of the system.

As mentioned previously however, electrical generation performance was not the only criteria with this installation, providing shading of the 4th floor west facing windows was also a major concern. Therefore, the installation of this array has resulted in the addressing of the shading issue as intended, as well as providing some extra renewable energy generation capacity to the building.

Explanation/reasons for difference

The main reason for the difference between the predicted and actual performance of this polycrystalline solar array, is that the recorded data is only showing the summer performance of the system. The predicted output value is an average across an entire year, and so takes into account the expected lower output of the system throughout the winter period. Once the system has been in operation for a full year, then a much more accurate analysis of the system output performance can be undertaken.

5.4.3 Amorphous PV array – Solar Pergola

Predicted Performance

The predicted system generation capacity was calculated based on the assumptions listed in the first year building report. The total annual energy contribution due to this Solar PV array was predicted to be 1.3 MWh. Using the assumption that the system was operational 365 days per year, then we have:

$$\begin{aligned} \text{Predicted Average Daily Generation} &= 1.3 \text{ MWh} / 365 \text{ days} \\ &= 3.56 \text{ kWh/day} \end{aligned}$$

Actual Performance

Electrical energy generated by the system is monitored through the buildings metering system. The actual electrical energy generated during the analysis period is **0.895 MWh**.

$$\begin{aligned} \text{Actual Average Daily Generation} &= 0.895 \text{ MWh} / 365 \text{ days} \\ &= 2.45 \text{ kWh/day} \end{aligned}$$

Therefore, we can see that the difference between the predicted performance of the solar PV array is:

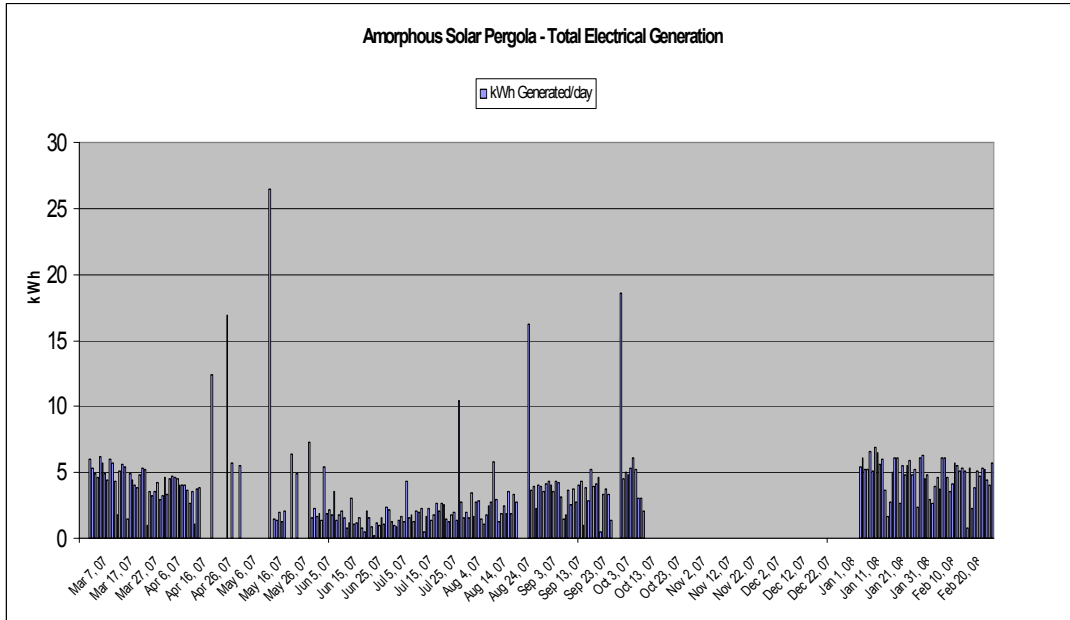
$$\begin{aligned} \text{Difference} &= \text{Actual performance} - \text{Predicted performance} \\ &= 2.45 \text{ kWh/day} - 3.56 \text{ kWh/day} \\ &= - 1.11 \text{ kWh/day} \end{aligned}$$

Table 5.6: Predicted vs. actual output performance

	Daily generation (kWh)	Annual generation (MWh)
Predicted Performance	3.56	1.3
Actual Performance	2.45	0.895
Difference	- 1.11	- 0.405
	- 31.2%	- 31.2%

At present, the amorphous solar array is not performing as well as what was predicted in the initial design specification.

Graph 5.3: Amorphous PV Electrical Energy Generation



As can be seen from figure 5.4 above, the Amorphous PV array was not generating any power over the period from October 14 2007, through to January 7 2008 – a total of 86 days. This was due to water ingress of the exposed conduit work, DC isolator, and inverter cubicle of this system. This water damage caused the DC isolating switch to open circuit, and thus not allow any power generated by the array to flow through to the inverter. This problem has now been fixed, as it can be seen that power is now being generated by the system from January 7 onwards.

Taking this breakdown into account, the average daily generation of this system would then actually be greater than the predicted value. That is, if we include the power generated by the system over the same time period the previous year, then the total electrical energy generated over the analysis period is 1.35 MWh.

Also, the ‘spikes’ in the graph can be attributed to the same metering problem as mentioned previously for the polycrystalline array.

The seasonal variation in output performance from summer to winter of the amorphous solar PV array is much less relative to the polycrystalline solar PV array. This is shown in table 5.7 below.

Table 5.7: Seasonal Variance of amorphous and polycrystalline PV arrays

Array Type	Average Electrical Generation (kWh/day)			Variance from Total Year (%)	
	Summer	Winter	Total Year	Summer	Winter
Amorphous *	4.97	2.20	3.69	34.7 %	40.4 %
Polycrystalline	21.98	5.87	13.94	57.7 %	57.9 %

* NOTE: Values from previous year have been substituted for period of time that array was not generating power due to water damage of DC control system

Explanation/reasons for difference

The main reason for the difference between the predicted and actual performance of the amorphous PV array, is due to the water damage which caused the system to be non-operational for a significant period of time. If this breakdown had not occurred, or had been identified earlier, then the actual output of the system would have been expected to be greater than the predicted design amount.

Regular monitoring and maintenance of all the on-site generation systems should be implemented, to ensure that such issues are identified and remedied as quickly as possible. Also included as part of this program, should be the regular cleaning of solar panels to ensure year-round maximum output performance of all solar PV systems.

5.4.4 Ceramic Fuel Cell

Predicted Performance

The fuel cell was intended to produce 1 kW of electricity to supplement the electrical energy supplied from the electricity grid, and 1 kW of heat which was expected to meet 90% of the domestic hot water requirements of the building. The total annual electrical energy contribution due to this fuel cell was predicted to be 9 MWh, as well a 1 kVA reduction in the site electrical demand.

The fuel cell was predicted to consume 2.5 kW of gas during normal operation, and was expected to run 24 hours per day, 7 days per week, 365 days per year. Using this situation, we have a predicted annual energy consumption of:

$$2.5 \text{ kW} \times 24 \text{ hours} \times 365 \text{ days} = 22 \text{ MWh/year} = 79,000 \text{ MJ/year}$$

This natural gas consumption was listed as hot water energy use in the initial design calculations, with the electrical energy generated (ie 9 MWh/year) considered as 'free' energy. From information supplied from the fuel cell manufacturer, the natural gas consumption will vary depending on the stack performance, i.e. the fuel utilization level, in the following ranges as depicted in Table 5.8

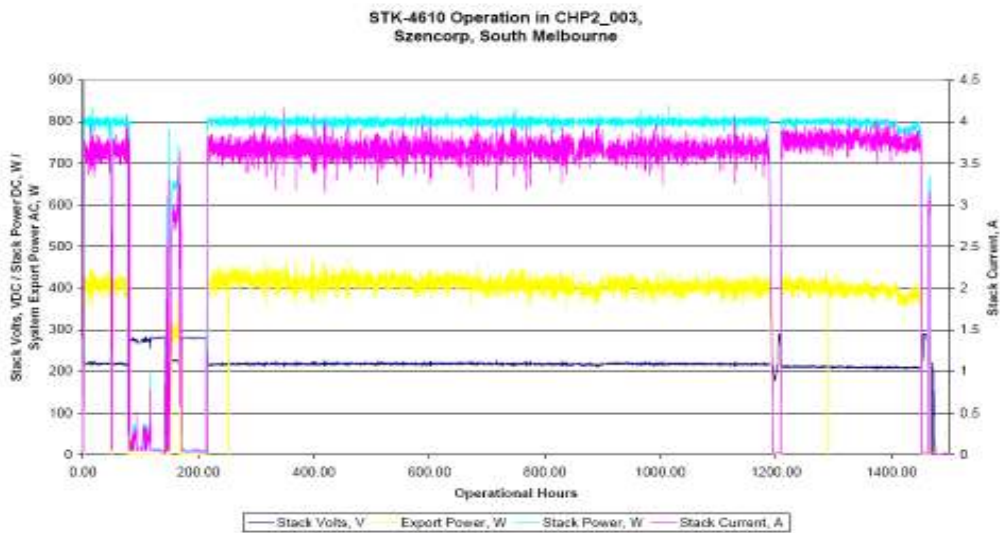
Table 5.8: Fuel Utilisation Level

Stack Performance	Natural Gas Consumption
250 W	100 – 150 MJ/day
500 W	200 – 250 MJ/day
1000 W	300 – 400 MJ/day

Actual Performance

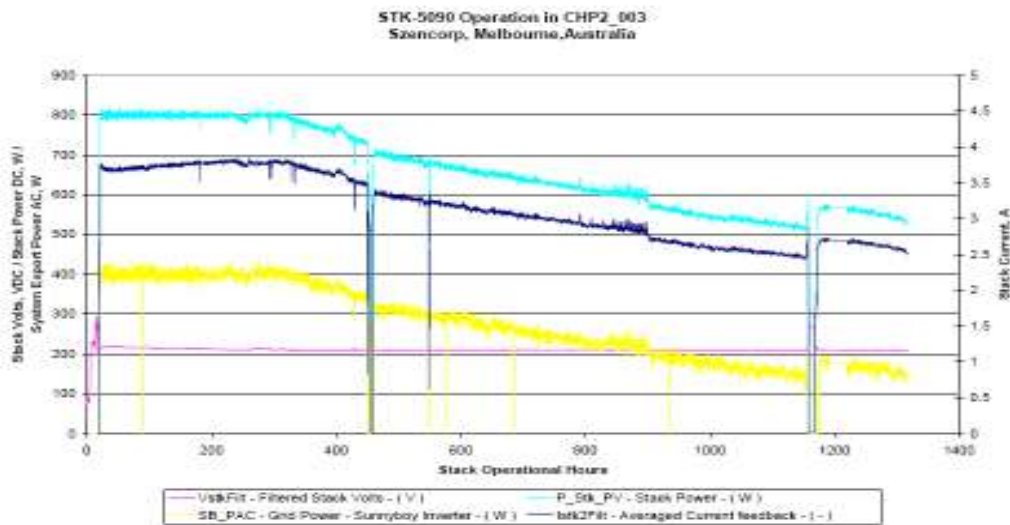
Graphs 5.4 and 5.5 below show the performance plots of the various fuel cell stack operation.

Graph 5.4: Ceramic Fuel Cell – Stack 4610 Operation



Stack number 4610 was installed 12th February 2007 and was shut down on 17th April 2007. As can be seen, a constant 400W of export power was sent to the grid over this period of operation.

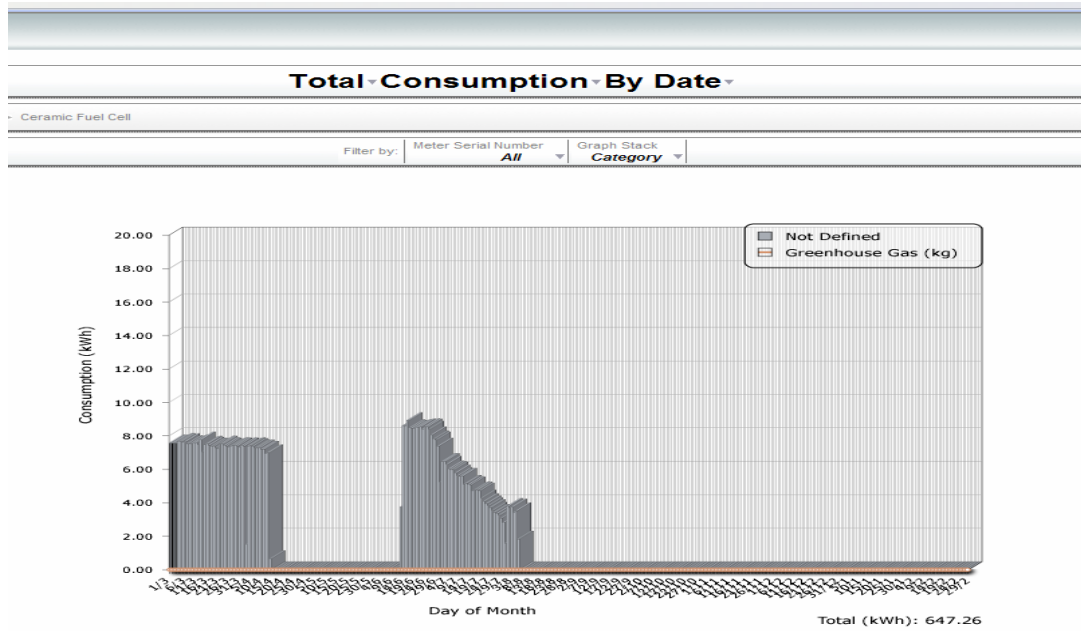
Graph 5.5: Ceramic Fuel Cell – Stack 5090 Operation



Stack number 5090 was installed on 12th June 2007 and was shut down on the 8th August 2007. As can be seen this stack started at an export power of 400 Watts, which over the trial period slowly reduced to an end export value of just under 200 watts. The system has been in hibernation since the 8th August 2007, and thus is currently producing no electrical energy, or thermal heat energy for hot water.

Image 5.2 below shows the total electricity generated by the fuel cell unit over the period 1st March 2007 through to 1st March 2008 as recorded by the building’s metering system.

Image 5.2: Ceramic Fuel Total Electrical Generation 1/3/2007 to 1/3/2008



From image 5.2 above, the two definite generation periods for the two different stack configurations can be easily seen. Cell stack 4610 generated a fairly constant output of approximately 7.5 kWh per day over its operational period. Cell stack 5090 started generating at a slightly higher output value, and then slowly tapered off the amount of daily electrical generation until it was finally shut down.

The total electrical generation of the fuel cell unit for the period 1st March through to 1st March 2008 is **647.26 kWh**.

$$\begin{aligned} \text{Actual Average Daily Generation} &= 647.26 \text{ kWh} / 365 \text{ days} \\ &= 1.77 \text{ kWh/day} \end{aligned}$$

Therefore, we can see that the difference between the predicted performance of the fuel cell is:

$$\begin{aligned} \text{Difference} &= \text{Actual performance} - \text{Predicted performance} \\ &= 1.77 \text{ kWh/day} - 24 \text{ kWh/day} \\ &= -22.23 \text{ kWh/day} \end{aligned}$$

Table 5.9: Predicted vs. actual output performance

	Daily generation (kWh)	Annual generation (MWh)
Predicted Performance	24	8.76
Actual Performance	1.77	0.647
Difference	- 22.23	- 8.133
	- 92.6 %	- 92.6%

At present, the fuel cell is not performing as well as what was predicted in the initial design specification.

Explanation/reasons for difference

The main reason that the fuel cell is not generating as much electrical energy as was predicted in the initial design specification, is due to that the fact that this fuel cell unit is a field trial unit, and is therefore undergoing continual assessment, testing, and configuration modifications. At present the fuel cell is in hibernation mode and is not generating any energy. The fuel cell unit is expected to be de-commissioned later this year.

5.4.5 Total on-site renewable energy contribution to building consumption

Outlined in table 5.10 below is the total amount of electrical generation from all of the onsite generation systems for the analysis period 1st March 2007 through to 1st March 2008.

Table 5.10: Total On-site Renewable Energy Generation

System	Actual Daily generation (kWh)	Actual Annual generation (MWh)
Polycrystalline Array - Rooftop	13.94	5.08
Polycrystalline Array – Western shading level 4 windows	7.59	2.77
Amorphous – Solar Pergola	2.45	0.895
Ceramic Fuel Cell	1.77	0.647
Total On-Site Renewable Generation	25.75	9.39

The total electrical consumption of the Szencorp building for the last 12 months is **67.766 MWh**.

Therefore the percentage of the building's electrical consumption met by the on-site renewable energy generation systems is:

$$= 9.39 \text{ MWh} / 67.766$$

$$= \mathbf{13.86 \%}$$

5.5 ONGOING INVESTIGATIONS

5.5.1 Wind turbine data analysis

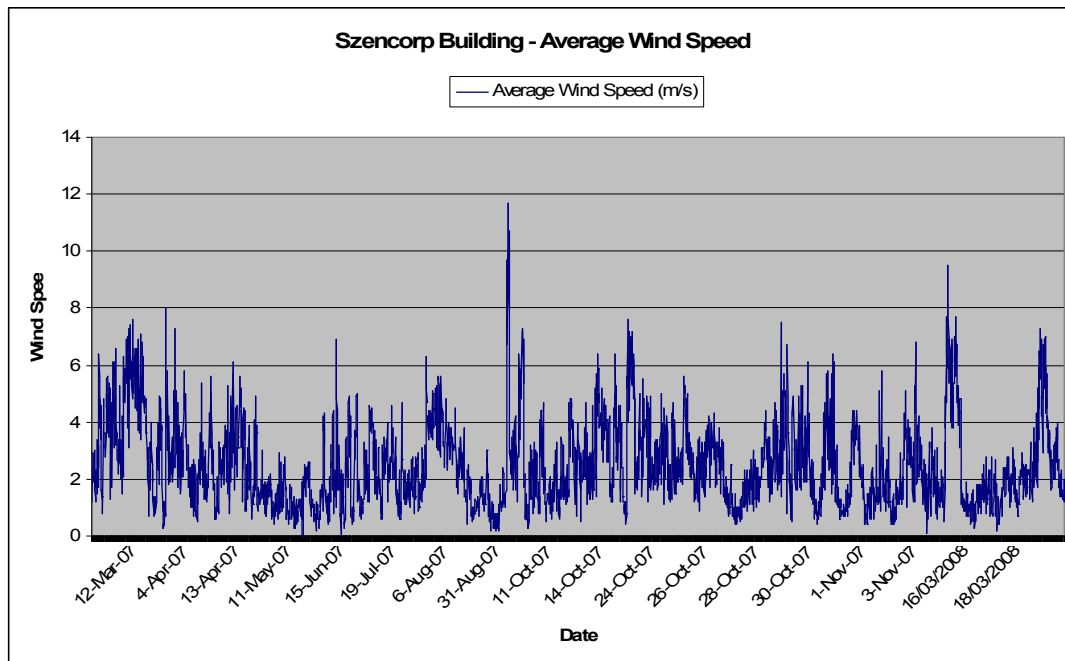
The Building Management System (BMS) of the Szencorp building logs a large number of variables, one of those being the average wind velocity as measured by the rooftop weather station.

One of the recommendations of the 1st year building report was to monitor the wind velocity data recorded by this weather station for a period of 1 year. The intent being to investigate the feasibility of installing a wind turbine to increase the renewable energy generation capacity of the building.

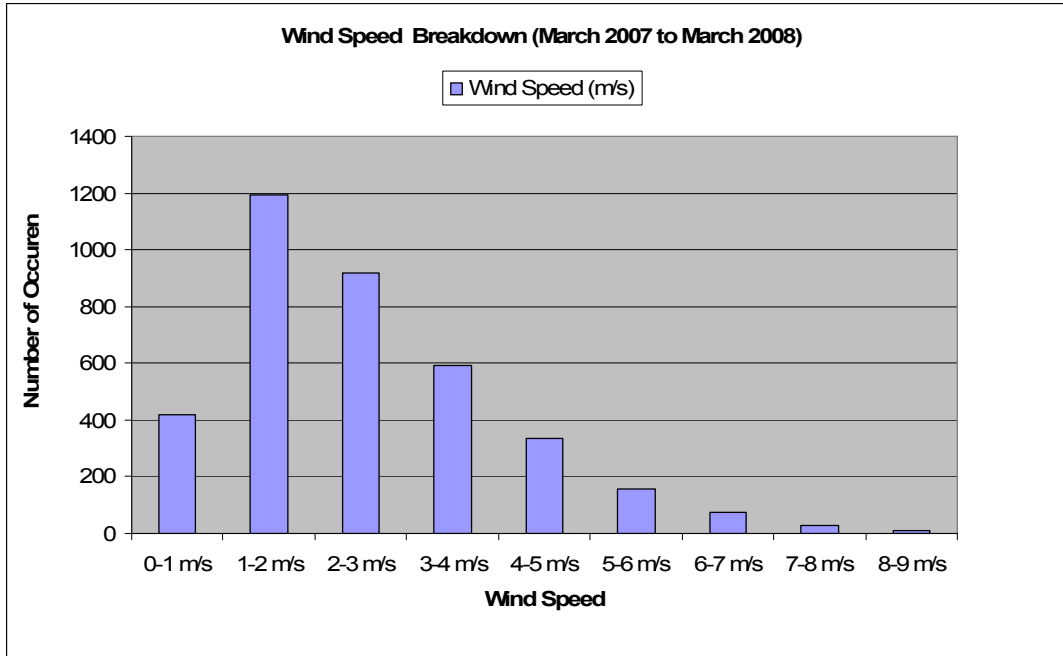
Figures 5.8 And 5.9 below, display the captured wind data information from the Szencorp building weather station. The information recorded by the BMS is an average wind velocity over a fifteen minute sampling period. Therefore, instantaneous wind speeds may actually be higher than what is shown, however only the average value over the fifteen minute period is what is displayed in the graphs.

This average value is important in determining a site's suitability for the installation of a wind turbine, as it is the presence of strong consistent wind speeds which is critical, not high gusty values which only last a short period of time.

Graph 5.6: Average Wind Speed – Szencorp Building



Graph 5.7: Average Wind Speed Breakdown – Szencorp Building



Average wind speed over 1 yr period: 2.5 m/s
 Highest recorded wind speed over 1 yr period: 11.7 m/s
 Percentage of time wind speed > 5m/s: 7.1 %

As can be seen from the two figures above, the average wind speeds present at the Szencorp building site are quite low. The normal cut-in wind speed required for a wind turbine to start generating any useful power is at least 5 m/s. Over the 1 year recording period, the proportion of time that the wind speed was high enough for a wind turbine to produce any power at all was only 7.1%.

This therefore suggests that this is not a suitable site for the installation of current generations of wind turbine technology to generate electrical energy.

5.6 RECOMMENDATIONS FOR FURTHER TUNING

Outlined briefly below are some recommendations for increased renewable energy generation that would assist the Szencorp building in its vision of becoming a net exporter of electrical energy.

5.6.1 Further PV array installations

Installing similar solar PV arrays to the western end 1st, 2nd, and 3rd floor windows, as that which is currently installed over the western end 4th floor windows. Although this option presents a very high payback period, it would serve the dual purpose of increasing the renewable energy generation capacity of the building, as well as provide shading to all of the west facing windows.

Table 5.11: Recommendation for performance Improvement – PV array installation

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (Tonnes)	Payback period (Yrs)	Comment
Install similar PV arrays as that currently installed over Level 4 windows, to the remaining western windows.	\$ 105,000	\$ 795	8.8	132	Obviously this would not be considered on payback period alone. It would however serve the dual purpose of solar shading for the western windows, as well as increase the renewable energy generation capacity of the building by approximately 6 MWh/year.

5.6.2 Modifications to existing roof top PV array

Implement the recommendation listed in the 1st year building report of modifying the array mounting frame associated with the large polycrystalline PV array on the rooftop. Modifications to alleviate the self-shading problem would bring about an expected output generation performance increase of approximately 2 MWh per annum from this array.

Table 5.12: Recommendation for performance Improvement – PV array modification

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (Tonnes)	Payback period (Yrs)	Comment
Modify mounting of existing polycrystalline PV array in order to overcome self – shading problem.	\$ 5,000	\$ 265	2.9	18.8	This issue was raised in the first year building report, so refer to this document for full description.

5.6.3 Implementation of ongoing maintenance and monitoring programme

Implement a regular ongoing monitoring and maintenance program of all on-site generation systems immediately. Such a program would help to ensure that all systems are always operating at their maximum potential, and also allow for the quick and immediate identification of any system faults if and when they occur.

Table 5.13: Recommendation for performance Improvement – Monitoring & maintenance programme

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (Yrs)	Comment
Regular ongoing monitoring and maintenance of all onsite generation systems to ensure optimum output, and prompt identification of any system faults		TBC*			This will help ensure that issues such as the solar pergola breakdown are identified and remedied as early as possible.

**A proposal for ongoing monitoring is to be issued in conjunction with the submission of this report.*

CHAPTER SIX | METERING

The metering system at 40 Albert Road has required regular attention since inception and continues to offer challenges. Overall, the system has effectively enabled ECS staff to identify a number of functional issues with other systems within the building which have since undergone rectification. There are further areas where the unavailability of data limits the potential to fully interrogate the performance of individual services.

6.1 METERING SUMMARY

Table 6.1: Recommendations for performance improvement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Identify and improve the data collection and reporting functions of installed metering	unknown*	\$0	0	N/A	This measure is also included in the HVAC & DHW section of the report. Please see 2.5.1
Re-instate metering to the rainwater capture and grey water recovery systems after works to upgrade the system completed.	\$150	\$0	0	N/A	Required for data collection and interrogation purposes, this recommendation also included within the water section of the report

* ECS will provide a proposal for the costing if this recommendation is to be pursued further by the 40Albert Rd.

6.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

There have been numerous changes to metering equipment and settings over the past year. Metering is important in the identification of plant performance and maintaining the ability to respond rapidly to detection of consumption outside the expected range, a scenario such as leakage or faulty equipment. The following table 6.2 indicates the first year recommendations for the metering systems.

Table 6.2: Table of all First Year Metering System recommendations

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Install gas and electricity metering for the gas heat pumps	\$3100	\$0	0	N/A	This may be used to evaluate the performance of the units	Implemented See 6.2.1
Install electricity metering on the FCUs, outside air fan, toilet exhaust fan and ventilation fans	\$3500	\$0	0	N/A	This may be used to evaluate the performance of individual fans	Funding was not granted for this measure
Provide a virtual building meter to show total building consumption	\$0	\$0	0	N/A		Not Implemented

6.2.1 Installation of gas and electricity metering for the heat pumps

On the 3rd January, gas and electricity metering installations for the rooftop heat pumps commenced and have been providing data connected directly through to the building metering and monitoring systems. This data assists the performance evaluation of the units. Currently the units are performing within specification; consequently the data has not led to the identification of energy conservation recommendations for the units. The monitoring system has the capability of flagging high consumption incidents for review, although there have been none to date.

Table 6.3 Results of Energy Control Measure – gas and electricity metering on heat pumps

Recommendation	Date Implemented	Predicted Cost Savings	Predicted tCO2 Reduction	Actual Cost Savings	Actual tCO2 Reduction
Install gas and electricity metering for the gas heat pumps	3 rd January 2007	\$0	0	\$0	0

6.3 SECOND YEAR METERING CHANGES

6.3.1 Modifications to metering structure

On the 5th January 2007, further modifications were made to the metering structure. These metering installations with particular reference to the roof top services included both gas and electricity sub-metering. Such sub-metering now allows for system performance review at greater detail and had led to the identification of a number of system improvements. The installation works are of reasonable quality; however the final result maintains a few opportunities for improvement. The most concerning issue is the labelling and identification of the metering which lacks clarity, consequently the data produced can be difficult to interpret at first glance.

6.4 SECOND YEAR METERING PERFORMANCE

The building's metering system consists of 56 meters providing energy monitoring and control services through collection of interval data from all electricity, gas and water meters. It collects stored interval data from the following meters:

- Ampy Q4 (Three Phase)
- P1 (Single Phase) electricity meters
- Pulsed outputs from the Ampy gas meter
- Pulsed output from the Elster water meters

These meters are used to measure the following building components:

- Main electrical power on Ground level, Level 1, Level 2, Level 3 and Level 4.
- Lighting Circuits on Ground Level, Level 3 and Level 4.
- Kitchen appliances on Level 4 such as fridge, hot plates and hot water etc.
- Cogeneration from the Photovoltaic Solar Arrays and the Ceramic Fuel Cell on the roof.
- Mains, Rain and Grey water.
- Mechanical services board.
- Gas for hot water, HVAC units and the Ceramic Fuel Cell.
- General building power.

The electricity meters and associated equipment are co-located on a single metering panel within each main sub board on each level of the building. The water meters are located in the basement and gas meter is located on the roof of the building.

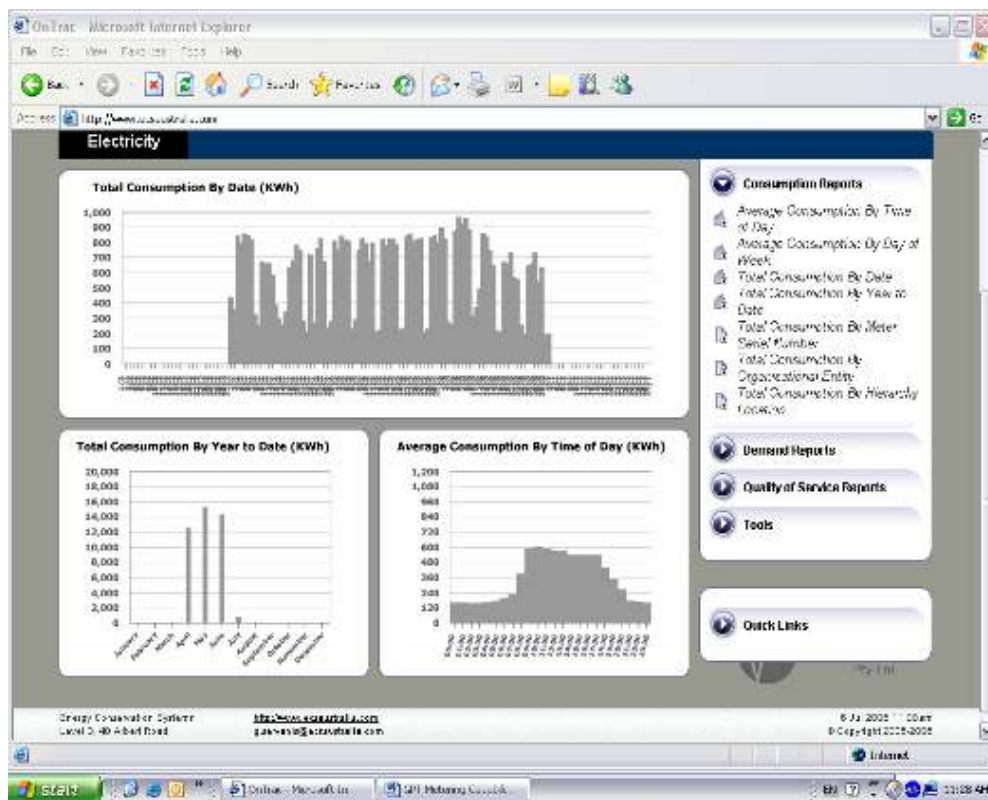
Web Login Interface

To login and view the energy data located on the web site the guest user must first log in and register via <http://www.ourgreenoffice.com/>. They will then be automatically be directed to the login screen shown below and enter the user name and password.

ECS's Energy Managers and guest web visitors are able to view energy, gas and water usage data in tabular and graphical formats over any selectable time period. Hierarchical filtering gives the ability to drill down and search for energy, gas and water consumptions and demands within a building. This also creates the ability to create custom filters to aggregate usage and to create benchmarks.

System alerts can also be provided which enables our building manager to receive alerts/alarms in the event of a threshold condition being exceeded. These alerts can be sent via email, SMS, facsimile. The building manager can then take the appropriate action to rectify the problem.

Image 6.1: Typical Dashboard summary of building electrical consumption



System features and functions

Notable features that the system provides are listed below:

- Virtual real time monitoring of electricity, water and gas
- 15 minute interval recording for Energy, Demand and Quality of Service parameters e.g.: kWh, kVAh, kW, kVA

- Intuitive hierarchical data presentation - drill down from building, area, plant, floor, etc
- Graphical and tabular reporting
- Automatic threshold alarms via email, SMS, facsimile e.g.: approaching Maximum Demand level, Power factor = 0.85, etc
- Max demand capability
- The use of state of the art “Power Line Carrier” technology whereby no cabling between meters and data concentrators is required which represents a significant cost savings in installation and commissioning costs.
- Near Real time SMS / Email alarms to alert the facilities/operations manager and or ECS staff to take the appropriate action to highlight and rectify any maintenance issues including any predefined profiles which are outside the minimum and maximum targeted based profile.
- Compatibility with revenue based tariff approved meters for on selling of electricity, gas and water within an embedded network.

System performance

Although the system does normally maintain a reasonable level of service and availability, the operation of the web interface is still cumbersome and frequently frustrating. The time required to locate desired data from the system is too long. Once obtained the confidence that the data is correct is too low. The following concerns need to be addressed as a matter of urgency;

- The mapping of metering is unclear; consequently the information requires regular ‘reality checking’ to see if it is actually indicating the correct figures.
- At least four gas meters are being interpreted by the system as electricity meters and providing gas consumption readings in kWh under the heading of electrical consumption.
- Virtual meters must not be treated the same as actual meters, these need to be highlighted as they are potentially unreliable. The changes to pipe works surrounding the Nubian grey water system means that the virtual meter described in the bullet points below is now again an incorrect formula.
- Likewise for the DHW gas use which has also been treated to pipe work modifications and meter movement.

6.5 RECOMMENDATIONS FOR FURTHER TUNING

6.5.1 Identify and improve the data collection and reporting functions

The metering reporting systems require attention, beginning with a review of the installed meter mapping to ensure equipment is correctly sub-metered. The method of identifying meters and recalling data should be simplified and made consistent across the meter types. At a glance there appears to be something in the order of 40 hours worth of system review and tidying required.

Table 6.4: Recommendations for performance improvement – data and reporting functionality

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Identify and improve the data collection and reporting functions of installed metering	unknown*	\$0	0	N/A	This measure is also included in the HVAC & DHW section of the report. Please see 2.5.1

* ECS will provide a proposal for the costing if this recommendation is to be pursued further by the 40Albert Rd.

6.5.2 Reinstate the recycled and rainwater metering

This recommendation is in progress and will be re-commissioned shortly. It should be considered in conjunction with recommendation 6.5.1 as the data recorded is only as useful as the ease and clarity of functionality for which the user interface allows.

Table 6.5: Recommendations for performance improvement – water metering

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Re-instate metering to the rainwater capture and grey water recovery systems after works to upgrade the system completed.	\$150	\$0	0	N/A	Required for data collection and interrogation purposes, this recommendation also included within the water section of the report

CHAPTER SEVEN | WATER SYSTEMS

As discussed in Chapter 1, 40 Albert Road is currently operating at 5-Star NABERS water rating which demonstrates the achievement of a very high level of water conservation and efficiency.

7.1 WATER SYSTEMS SUMMARY

Table 7.1: Recommendations for performance improvement

Recommendation	Capital Cost	Cost Saving \$	CO2 Saving (tonnes)	Payback period (years)	Comments
Re-instate metering to the rainwater capture and grey water recovery systems.	\$150	\$0	0	N/A	Required for data collection and interrogation purposes, this recommendation also included within the metering section of the report

7.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

Water performance in the first year was very encouraging apart from a leakage on the fuel cell which went unidentified for several days. In the second year the performance has improved again. The following table 7.2 indicates the recommendations made in the First Year Building Report.

Table 7.2: Recommendations for further water saving opportunities

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Increase grey water supply by switching the male toilets with the female toilets on levels 2 & 3		\$35	19.36 kL		Several options for increasing the supply of grey water were explored. These included re-piping to include grey water from men's hand basins, recovering water from dish washers, and the switching of male toilets with females ones on levels where the male to female ratio was higher.	Not Implemented
Maintenance required on taps and shower heads to ensure full compliance of to design specifications	Under warranty	Very little	0.48	Immediate	Taps and shower heads were checked for flow rates. The showers were running at 12l/min instead of the designed 9l/min. Most taps were operating according to design.	Implemented See 7.2.1

7.2.1 Testing of taps and showerheads

A review of the operating performance of the taps and shower heads was completed in line with the recommendations of the First Year Building Report. All taps and shower heads now perform to the design intent. The recommendation to modify pipe work arrangement from new sources to increase the grey water volume was not completed due to the costs associated and marginal savings available.

7.3 SECOND YEAR WATER SYSTEM CHANGES

During the course of the second year it was identified that the grey water system was not performing to expectation. Further investigation found that much of the water was being dumped to drain and the filtration vessels were clogged up, causing consumption of a greater volume of mains water than necessary. The total volume increase was marginal as full year results show excellent water performance for the second year, however further improvements appear to be available as a new grey water system has been installed to recover and reuse more water.

7.3.1 Grey water treatment

On 21 September 2007 a new grey water treatment system was purchased for the building. The new system has been installed and commissioned and incorporates a number of changes to the water piping arrangement in the basement of the building. New metering has been installed and this is in the process of being connected into the BMS system such that consumption data can be logged and assessed. Temporarily, data loggers are installed on the meters to provide this service.

The new system is produced by Nubian Water Systems and the model is Oasis GT600. The Oasis offers the latest technology in grey water recycling in a compact, low maintenance appliance. It treats water from the showers and hand basins of the female toilets. The system is fully automated and requires minimal maintenance. The unit is split into three vessels, the grey water tank, processor and the recycled water storage tank. Figure 7.1 indicates the general layout.

Water purification is achieved in three steps;

1. Pre-screening to remove lint and other coarse materials

To prevent blockages and fouling of the system the grey water is screened for lint and other coarse materials. This occurs at the inlet to the grey water holding tank. This tank is aerated to prevent the tank from going septic.

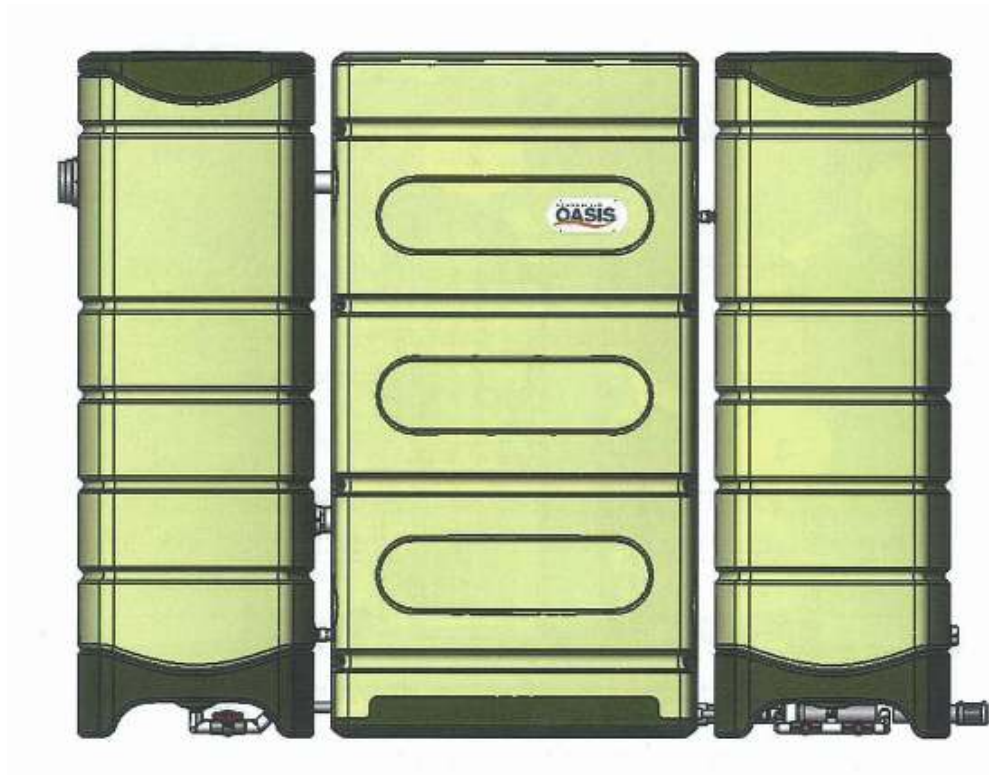
2. Processor treatment

Within the processor unit, the grey water is passed through proprietary media, with contaminant removal achieved through filtration, adsorption and biological treatment.

3. Ultraviolet (UV) disinfection

To complete the process the water is treated by ultraviolet disinfection before it is stored for re-use in the recycled water storage tank.

Figure 7.1 Oasis GT600 by Nubian Water Systems



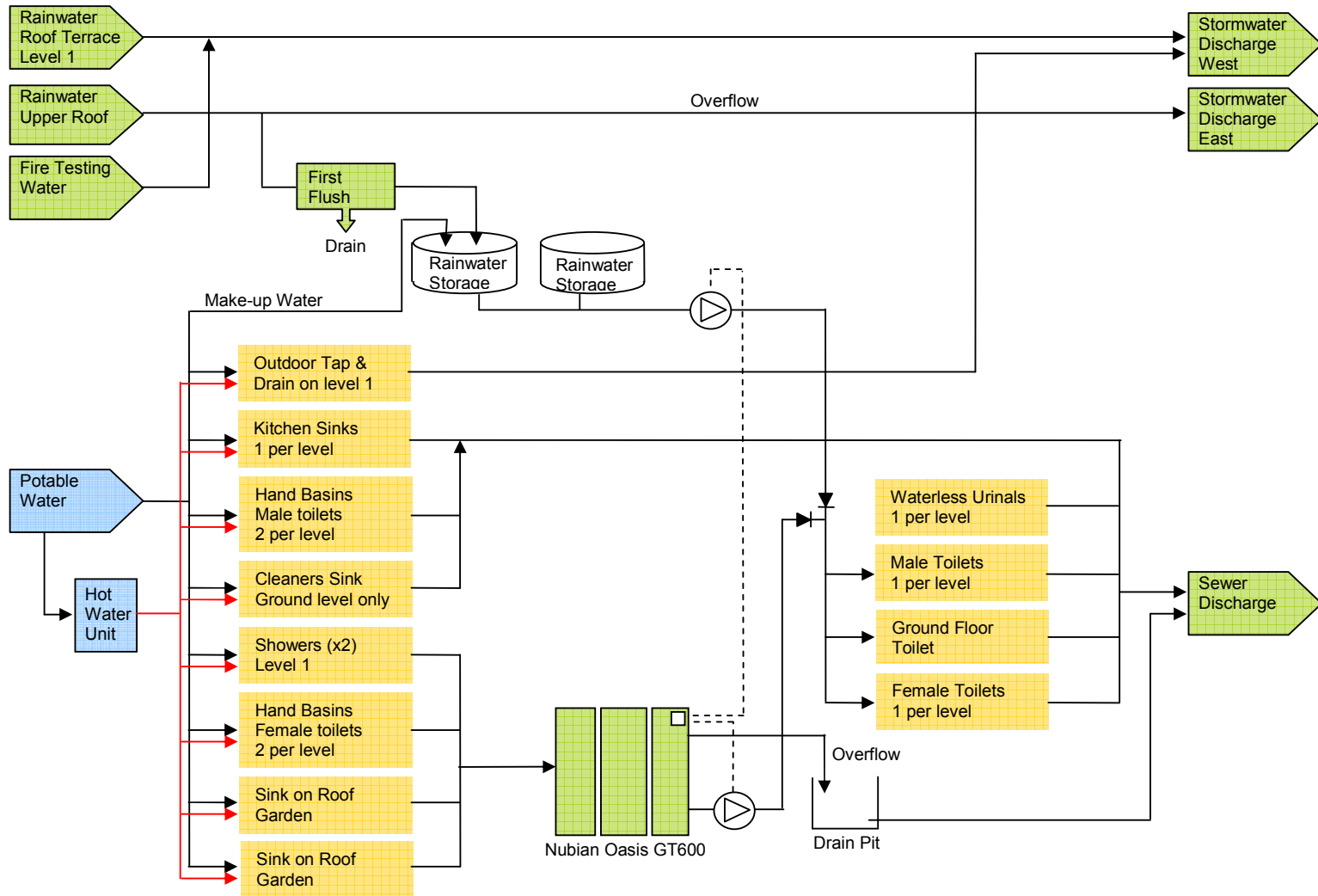
The recovered water output of the unit as a percentage of water recycled from the building is unknown. In order to determine this performance a meter installation is required in the delivery pipe work to the Nubian system, the performance of the system can then be determined by difference with the existing recovered water meter.

The general performance of the Nubian has been very good, with greater reliability and lower fouling than the previous grey water installation. The system has been put through its paces though with tenancy fit out workers on level 1 washing down plaster into the recycled water system, turning the water murky and grey. There is currently an investigation taking place to determine if the unit was damaged in the process. Now that the new pipe work and connections are made it is recommended that metering for this and the rain water collection systems are reinstated to the BMS and that the naming of these meters reflect their new location within the system.

7.3.2 Mains connection modifications

The previous pipe work connection orientation for the building failed to meet the separation requirements from the mains supply and was consequently changed in order to fully comply with regulations. At the time this work was completed the new grey water system was also installed and the revised water pipe work layout for the building developed. The figure 7.2 following details the newly installed system layout.

Figure 7.2: Water system layout for 40 Albert Rd



There is now a physical break between the mains water supplies and the rainwater and grey water systems. Such break is designed to eliminate the possibility of water flowing backward from our systems into the potable water network.

7.4 SECOND YEAR WATER SYSTEM PERFORMANCE

This chapter addresses the performance of all water systems within the Szencorp building. The analyses of the following water-related systems were undertaken:

- Grey water
- Rainwater collection
- Waterless urinals and dual-flush toilets
- Flow restrictors
- Overall mains water consumption

The building's water system has been carefully designed to conserve significant amounts of water, and has successfully achieved strong ratings within the NABERS water component. An investigation of water systems has indicated that further improvements can be made to meet the intended design as outlined in table 7.3.

Table 7.3: Water Systems Performance – Annual Consumption

System Consumption	Pre-installation Predictions	Post-installation results	Second year results	Comments
Toilets	106kL	70kL	68 kL	This is estimated using total consumption and eliminating all other known consumptions
Urinals	0kL	0kL	0kL	Urinals are waterless
Women's hand basins and Showers	65kL	12kL	8kL	This component is recycled for toilet flushing - also shown in table 7.3 as grey water supply.
Other sinks, basins and dishwashers	92kL	65.6 kL	39 kL	This is estimated using total consumption and eliminating all other known consumptions
Fuel Cell	Not predicted	1.34 kL	0 kL (system decommissioned)	This figure has been provided by CFCL based on current consumption
Total Potable Consumption	157 kL	100 kL	76 kL	

As can be seen, total potable consumption for the building is very low, achieving 5 star NABERS water rating with relative ease, see section 1.1. During the period 7th March 2007 to 6th March 2008 there have been no identified incidents of leakage.

Table 7.4 indicates the performance of the water supply streams.

Table 7.4: Water Systems Performance - Annual Supply

System Consumption	Pre-installation Predictions	Post-installation results	Second year results	Comments
Fresh Water	157kL (includes 0kL for flushing toilets)	100kL (includes 21kL for flushing toilets)	76 kL	
Grey Water	65kL	12kL	8kL	Grey water re-cycled from waste water from showers and women's hand basins.
Rainwater	41kL	37kL	31kL	

Table 7.5 below shows the annual water supply of grey water, rainwater and mains top up water used for the flushing of toilets. It can be seen that the grey water contribution is 11.76%, low in comparison to rainwater and mains top up.

Table 7.5: Overall Toilet Flushing water figures for 40 Albert Road

Source	Litres per annum	Proportion of toilet flushing supplied
Grey water	8,000	11.76%
Rain water	31,000	45.59%
Mains top up to tanks	29,000	42.65%
Output of tanks (Toilet flushing water)	68,000	100%

7.5 RECOMMENDATIONS FOR FURTHER TUNNING

7.5.1 Reinststate the recycled and rainwater metering

The Nubian system installation is complete and commissioned and the metering installation completed as part of these works now needs to be connected through to the BMS system in order to facilitate data logging. These works should proceed ASAP.

Table 7.6: Recommendations for performance improvement

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments
Re-instate metering to the rainwater capture and grey water recovery systems.	\$150	\$0	0	N/A	Required for data collection and interrogation purposes

CHAPTER EIGHT | LIFT

This section reviews the performance of the lift system with particular reference to the performance of the lighting and lighting control energy conservation measures implemented after the first year building report. The existing metering on the lift has allowed us to identify specific lighting and lighting control performance improvements since there are no changes to any other energy consuming function of the lift.

8.1 LIFT SUMMARY

No second year recommendations reported

8.2 REVIEW OF FIRST YEAR RECOMMENDATIONS

The recommendations regarding performance of the lift were limited to the lighting and lighting controls due to the high capital expense of any further mechanical changes to the system above what had already been spent prior to the first year building report.

Table 8.2: Table of first year lift recommendations

Recommendation	Capital Cost	Annual \$ Saving	Annual CO2 Saving (tonnes)	Payback period (years)	Comments	2 nd Year Status
Install motion sensor in lift to control lighting	\$1733	100.09	1.02	17.317	Also included in lighting chapter section 4.2.3	Implemented See 8.2.1

8.2.1 Installation of motion sensor in the lift

This energy saving measure was implemented with good energy saving results. The following table 8.3 summarises the performance of this energy control measure. The full details can be found within the lighting & lighting control chapter, section 4.2.3. Since this was the only modification to the energy consumption of the lift, the following second year lift performance section 8.4 will cover much of this information also.

Table 8.3 Results of Energy Control Measure – Motion sensor installation in lift

Recommendation	Date Implemented	Predicted Cost Savings	Actual Cost Savings	Predicted tCO2 Reduction	Actual tCO2 Reduction
Lift lighting controls	1 st March 2007	\$72	\$100	0.88	1.02

8.3 SECOND YEAR LIFT CHANGES

8.3.1 Lamp replacement

In conjunction with the occupancy sensor installation as detailed in section 8.2.1 and 4.2.3 there has also been a replacement of halogen lamps with two 11W Megaman compact fluorescent and one 6W LED on a trial basis. The overall energy reduction of re-lamping however individual lamps are not metered separately. The 6W LED trial is for perceived output, reliability and aesthetic testing.

8.4 SECOND YEAR LIFT PERFORMANCE

This section addresses the performance of the Szencorp building’s elevator. There is a single elevator which operates throughout the building from the basement car park to level 4 (6 levels in total). The elevator was used by the previous occupant and underwent certain modifications/modernisations in order to address a smoother/safer operation, code compliance and better energy efficiency. No further mechanical modifications are being investigated at this stage.

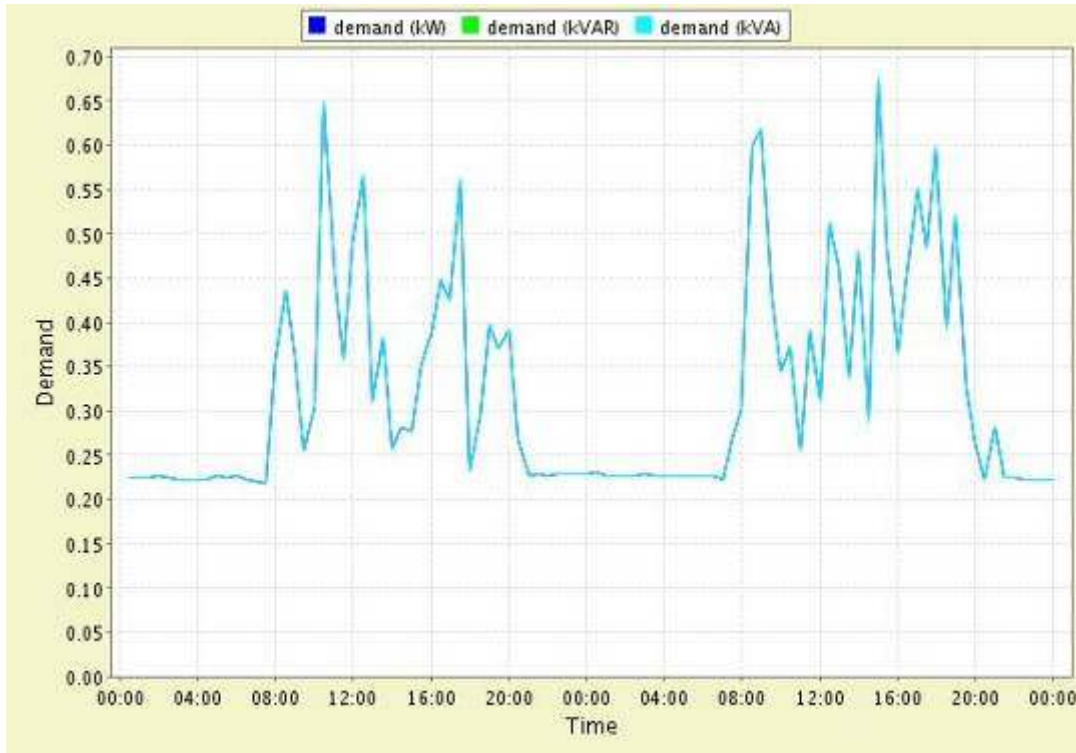
System performance

Lift performance identified within the first year building report indicated that the actual energy savings appeared to be approximately 486 kWh per annum, or around 16.5% better than the projected 2.95 MWh figure which represented consumption after modernisation works were completed.

Second year performance has produced further savings in lift consumption. The underlying basis for these savings is lighting and lighting control changes and reduced building occupancy. While occupancy reduction reduce the frequency of lift movements the following graphs are used to identify the different measures installed and the performance of each energy saving measure.

Graph 8.1 is re-issued from the first year building report and details lift demand over a two week day period during the first year building operation. It is followed by graph 8.2 indicating the demand curve over a two week day period during second year for comparison.

Graph 8.1: Lift energy demand during first year operation

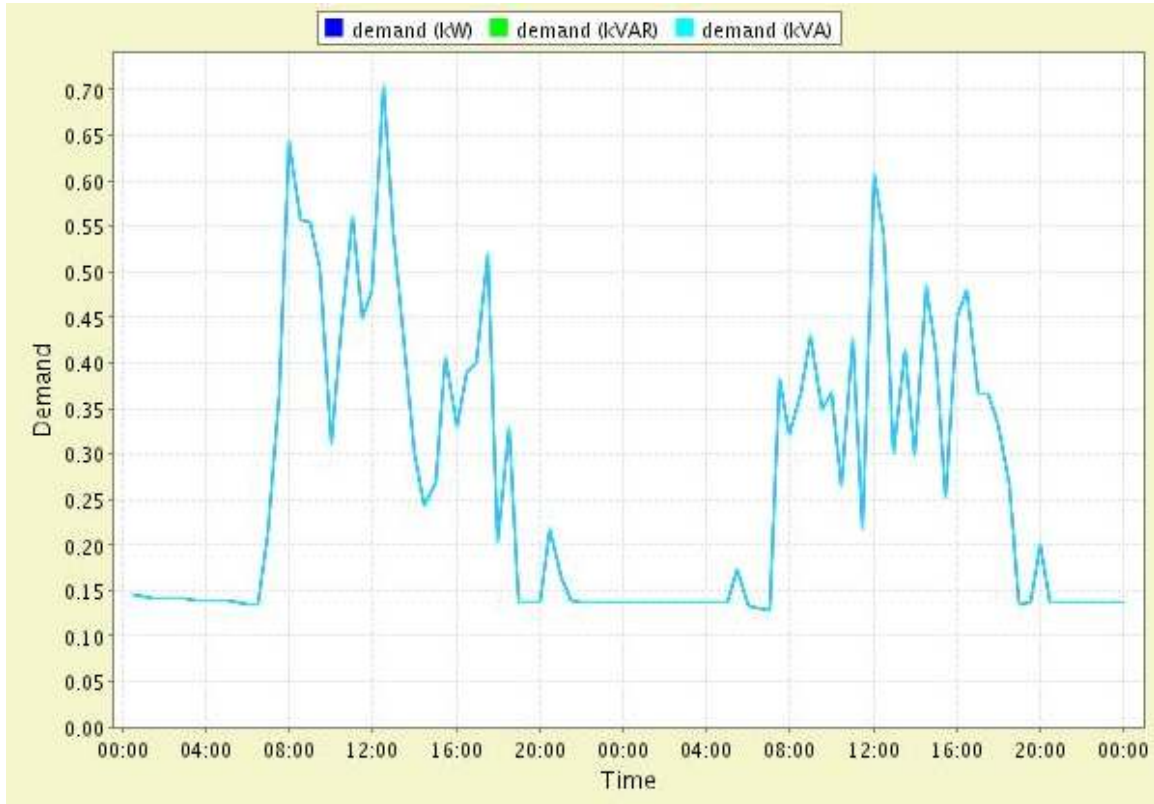


The graph 8.1 indicates a base load of approximately 225 Watts, which was attributed mainly to the lighting in the lift, which remained on all the time.

Graph 8.2 indicates a base load of approximately 140 Watts, some of which is still consumed by lighting as there is a single emergency light active which consumes a small amount of power. The remaining power consumption is the standing power for the lift in idle mode.

This is a clear indication that the occupancy sensing installation has delivered ongoing savings through the switching off of three of the four lamps present in the lift. The switch OFF delay is set to one minute.

Graph 8.2 Lift energy demand during second year operation



8.5 RECOMMENDATIONS FOR FURTHER TUNING

No second year recommendations are reported. The sensor switch OFF delay is currently set to one minute. The marginal energy saving which might be achieved through setting this delay to 30 seconds has been considered, however in such operation the potential for occupants to be left in the dark when standing still in the lift increases. It was felt that in an occupied small and moving space the potential for lighting to switch OFF should be avoided.

APPENDIX A | FIRST YEAR BUILDING REPORT