Woolley Building Retrofit
The University of Sydney

1. INTRODUCTION

PROJECT SUMMARY:
Partial retrofit of a heritage listed building at the University of Sydney. The retrofit is to accommodate the newly established United States Centre, which require offices, meeting rooms, catering areas and reception. The scope of work contains some elements of energy efficiency strategies, which are analysed for their impact on the building's energy consumption trends.

SPECIAL FEATURES
The first chilled beam system installed at the University of Sydney.

PROJECT MANAGER: Capital Insight
ARCHITECT: FJMT
OWNER: The University of Sydney

(Images source: The University of Sydney 2009)

UPGRADE Solutions & IEA SHC Task 47
Renovation of Non-Residential Buildings towards Sustainable Standards

2. CONTEXT AND BACKGROUND

• Original Building Age: 92 years - heritage listed

• Building Typology: General teaching building with offices

• Construction: Full brick

• Typology of plan: Courtyard Plan

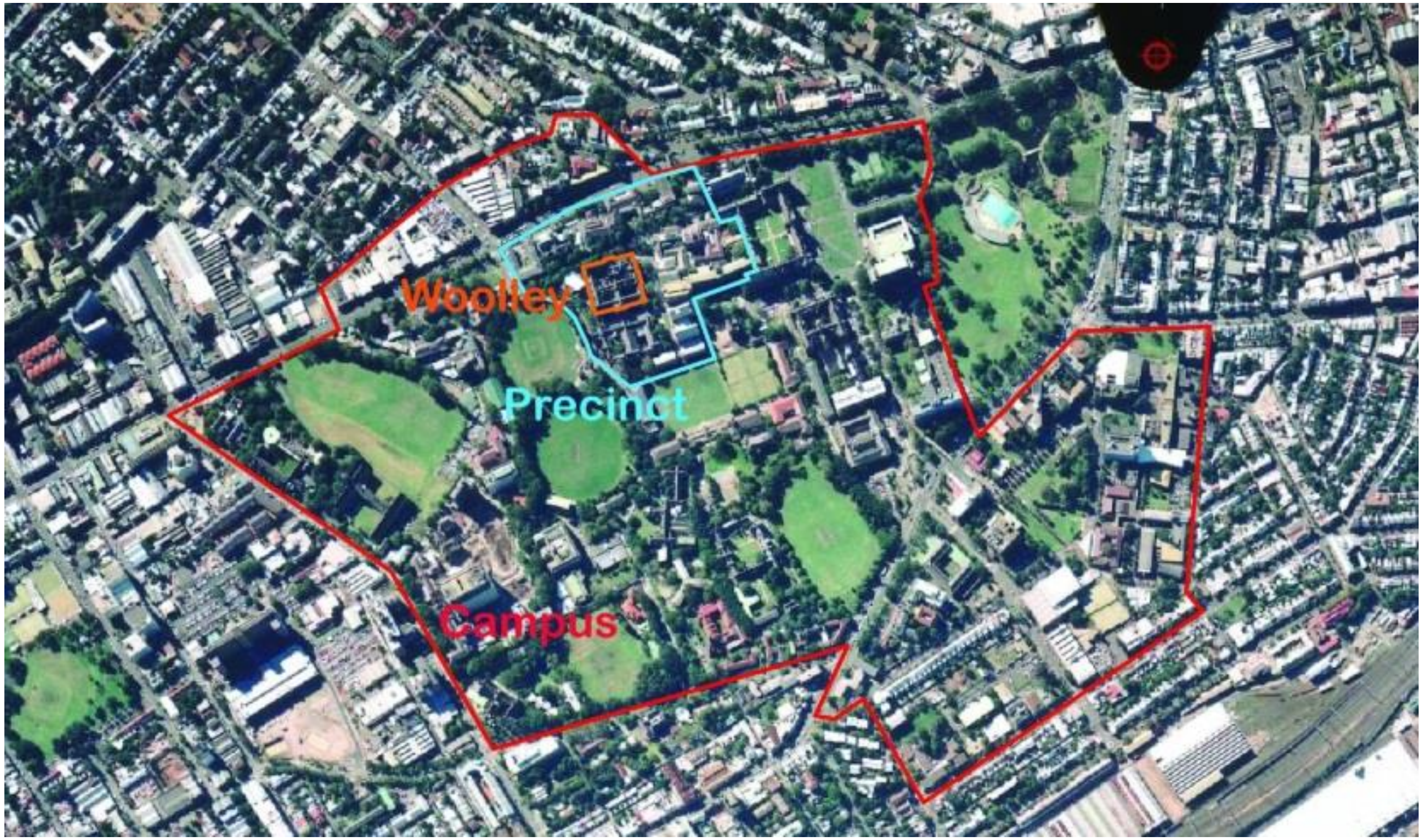
• Number of floors: 3

• Usage Floor Area: 1,600 m²

• Gross Floor Area: 2,250 m²

• Main Orientation: North & East

A partial retrofit of Woolley Building started in June 2007 and was completed in early January 2008.

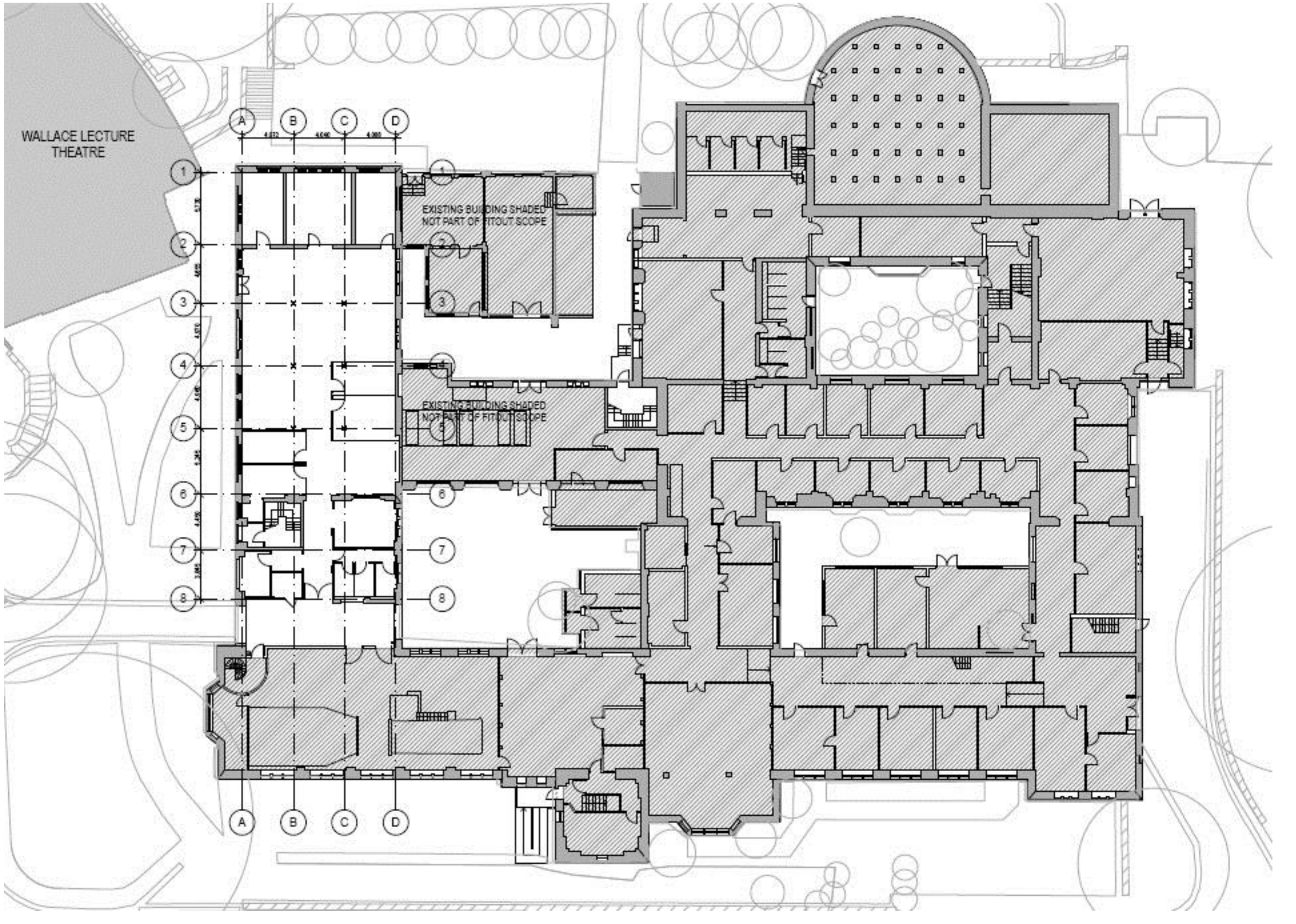


3. Scope of Work related to Energy Efficiency

Item	Description	Cost ($)
1	Chilled Beam System for cooling and ventilation	180,000
2	Compact Energy Efficient Lighting with flexible control	50,000
3	Timer control system for lighting and mechanical systems	4,000
4	Maximise glazing openings to allow sun penetration and natural lighting	6,000
5	Openings for natural ventilation, integrated with mechanical system.	9,000
	Total Cost:	249,000

4. BUILDING ENVELOPE

Plan of Woolley Building with the retrofit area sectioned and numbered.



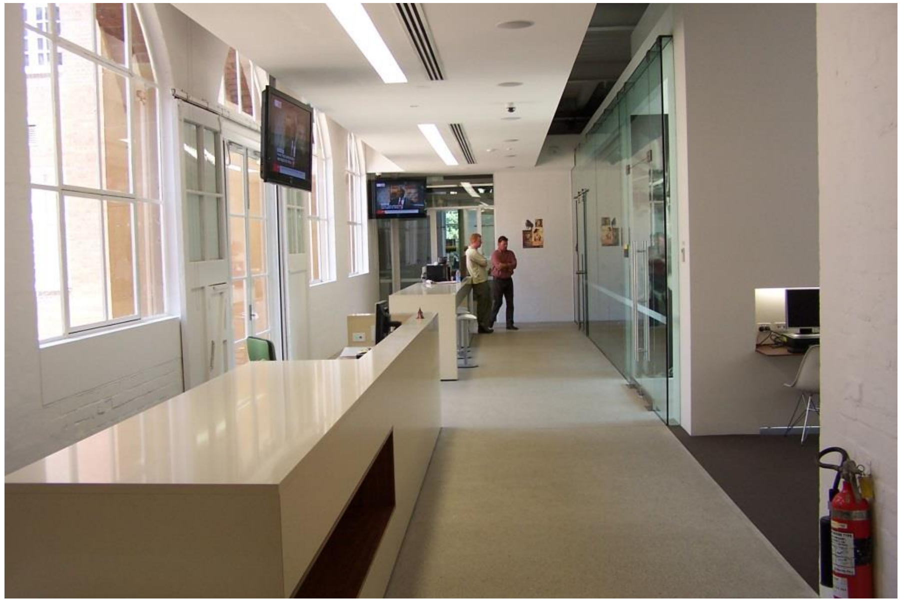
5. BUILDING SERVICES SYSTEM

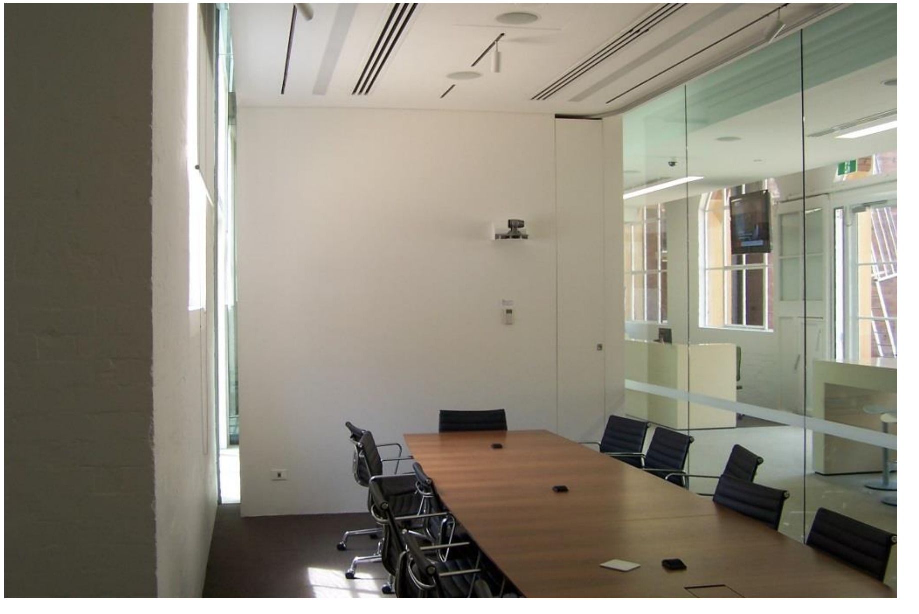
Active: Energy efficient lighting using energy efficient compact fluorescent luminaries. Each fluorescent tube requires 30-40% of the energy used by the previous lighting system, which was a conventional bulb and fluorescent setting. The lighting system is also designed to be turned off at the periphery to maximise the use of natural light and sun penetration.

Active: Control system with timer functions is installed to control both mechanical and lighting system. A timer activates the systems according to when the spaces are used. For out of hours operations, such as weeknights and weekends,

Passive: Natural light penetration is maximised by maintaining glazing openings, as well as addressing the orientation, sun penetration and the surrounding building context of the space. The design of work areas caters for use of abundant daylight, in an attempt to reduce the requirements for artificial lighting.

Passive: Natural ventilation
In parts of the space where air conditioning is not available, natural ventilation is encouraged through orientation and openings.





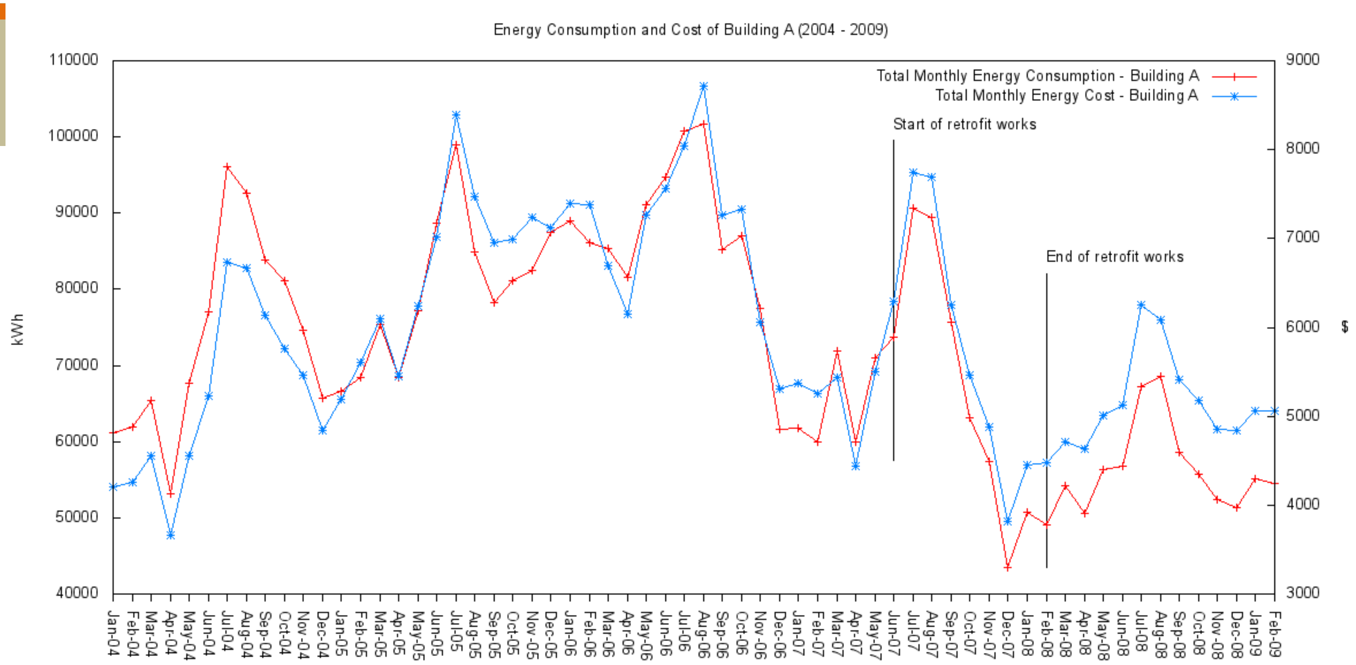
6. ENERGY TREND ANALYSIS

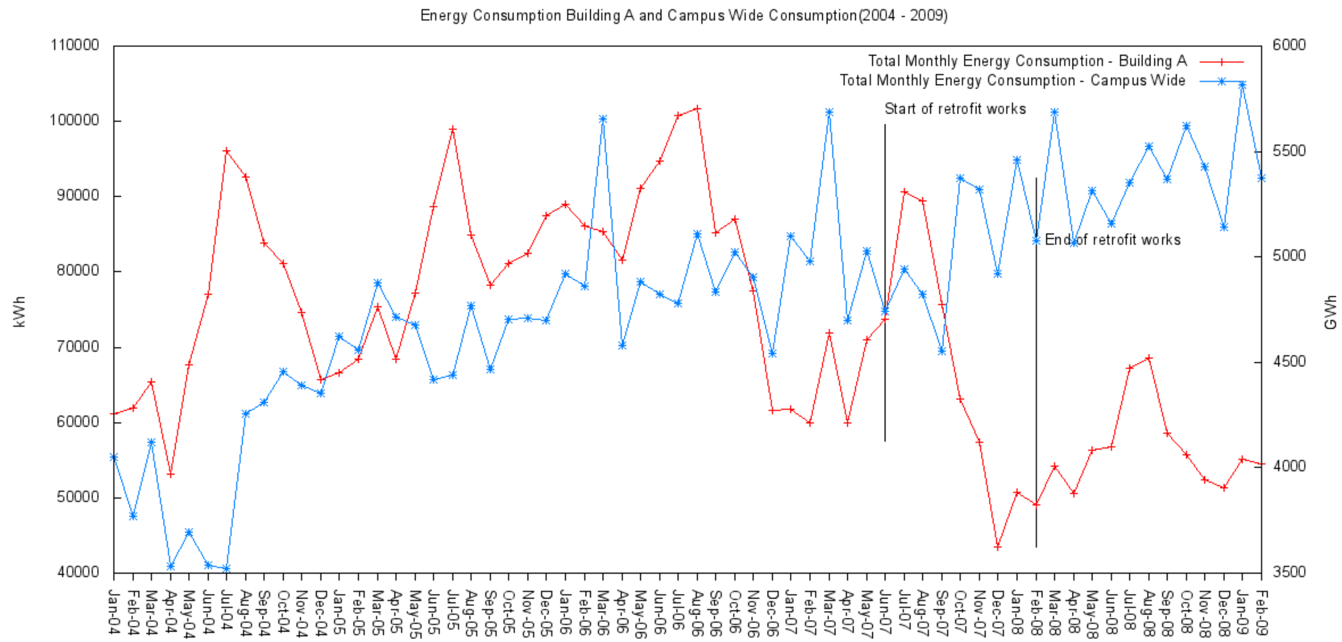
The energy source of the Woolley Building comprises of approximately 96% grid electricity and 4% gas. For the purpose of measurable consumption impact of this study, only electricity data is gathered and analysed.

- The average monthly energy consumption prior to the retrofit was 78,153.16 kWh to July 2007, in comparison with the monthly consumption in the post retrofit period of 56,768.93 kWh , a reduction of -27.36 % has been observed.

- The amount of energy saved in comparison with before the retrofit, is not equal to the amount of cost saved.

- A decline of 27.03% in energy consumption at the building level is contrasted with a total of 17.12% increase, from 4,590,801.24 kWh to 5,379,364.24 kWh at the campus level. The peaks and depressions at the campus levels do not correspond to that of the consumption at the building level.

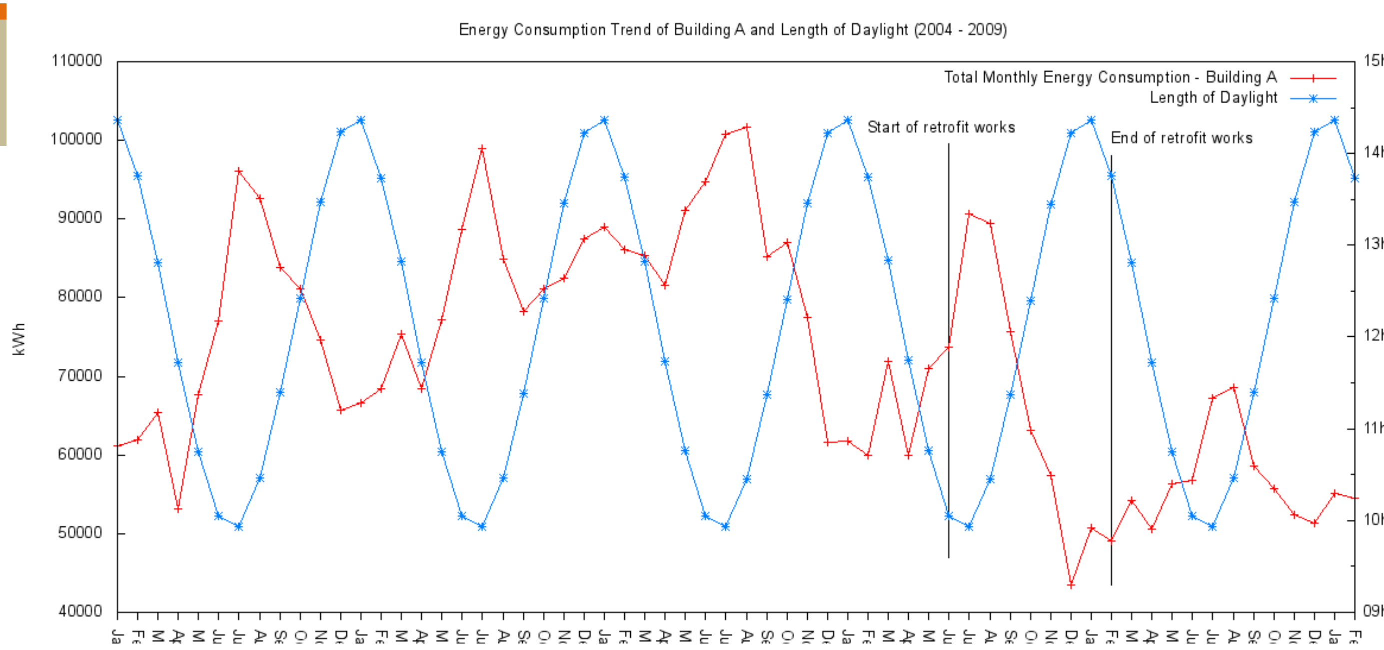


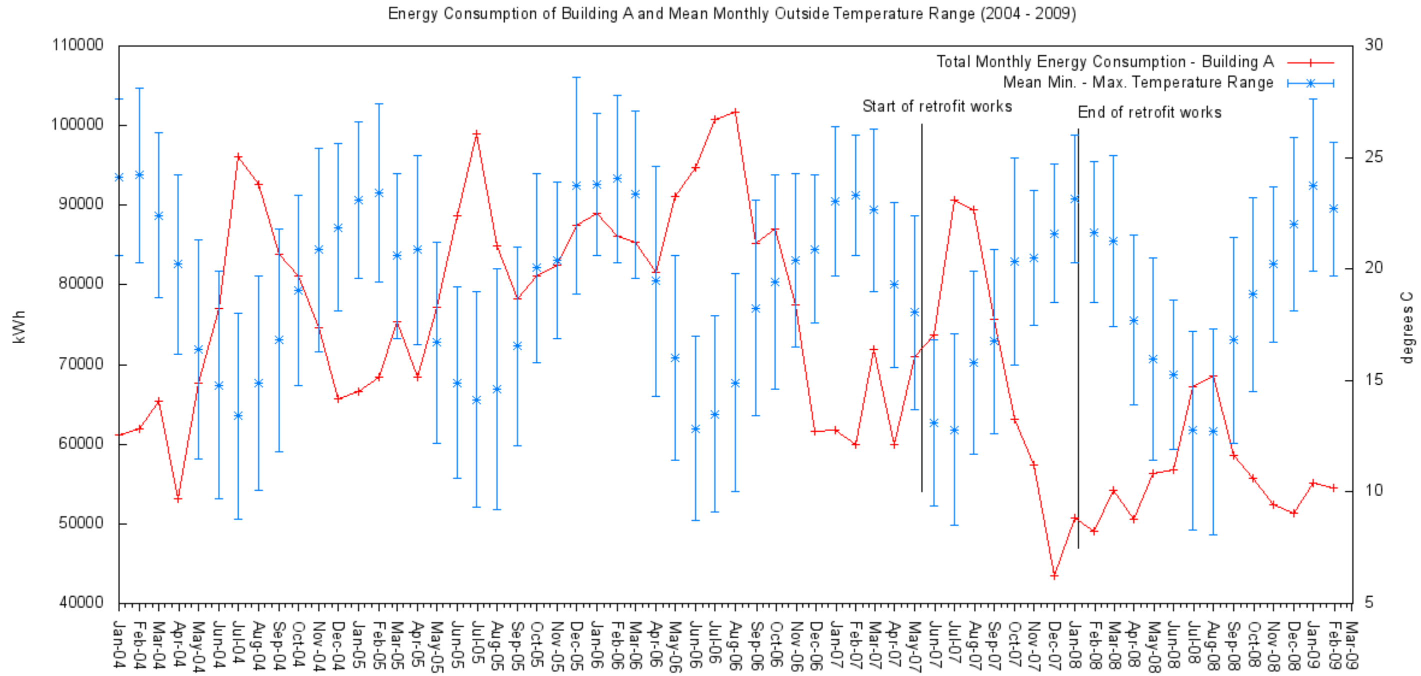


7. ENVIRONMENTAL PERFORMANCE

- the cycles of fluctuation in energy consumption appears to be directly inverse to that of the length of daylight cycles. This trend is observed both before and after the retrofit works. The recess in energy consumption in November to January each corresponds directly to the maximum periods in daylight lengths. This indicates that the building's energy consumption demonstrates a coherent relationship to the cycle of daylight, and seasonal temperature

- The building has a consistent trend of low consumption during summer (December - February), and high consumption during winter (June - August). This cyclical pattern continued after the implementation of the retrofit works, but at lower energy consumption intensity.

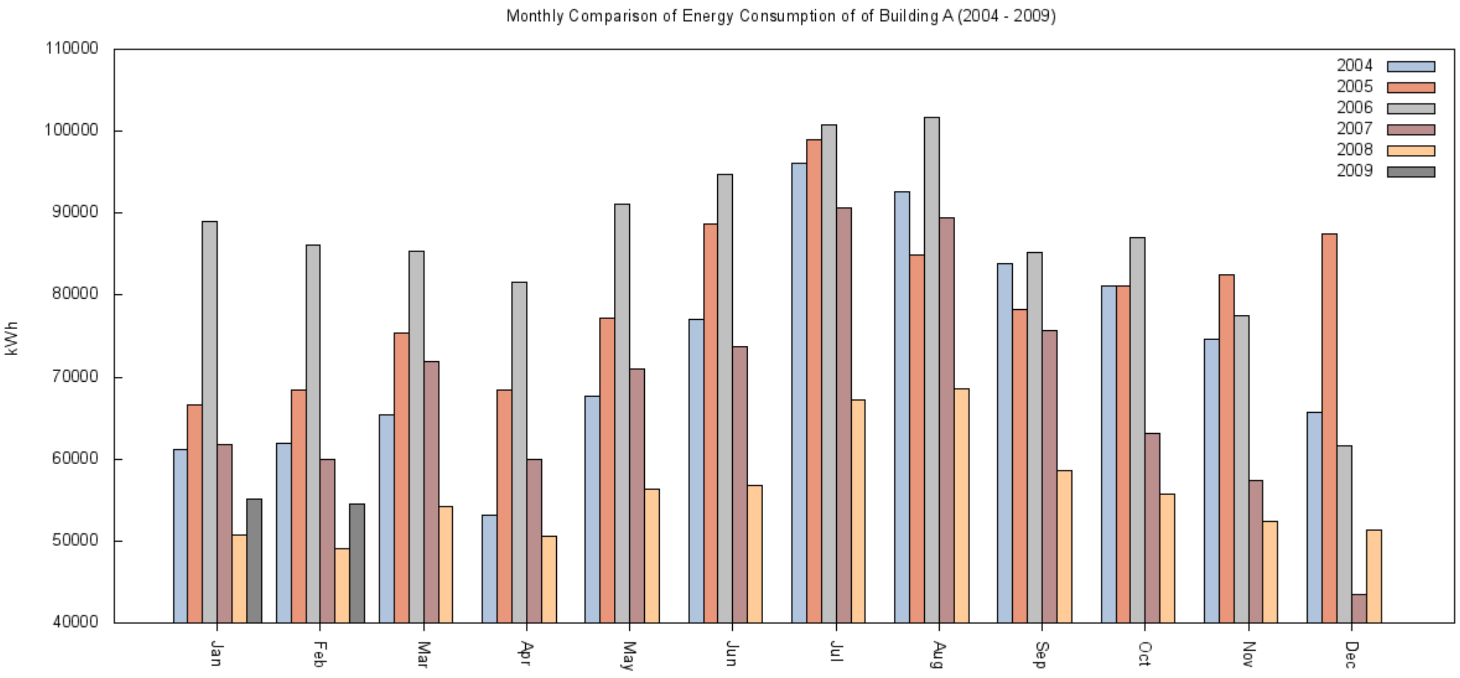




8. MONTHLY PERFORMANCE

- Post retrofit monthly consumption, after 2008, is significantly lower than during 2004-2007. The most significant consumption occurred in 2006, specifically noted in the month of August.

- Historically, peak consumption in winter was around 95,000 kWh per month to 100,000kWh per month. Although only the winter of 2008 is available for post retrofit analysis, the consumption was reduced to 60,000 - 70,000 kWh per month.



9. Before and After Retrofit

- A summary of changes in energy consumption, cost, connection with external variables, before and after the retrofit,
- Payback period calculated based on capital cost and materialised energy savings.

	Before retrofit	After retrofit	% Change
Mean monthly energy consumption (kWh)	78153	56769	-27.03
Mean monthly energy cost ($)	6170	5185	-15.97
EUI (Energy Utilisation Index) kWh/m²/yr	416.82	302.77	-27.03
Consumption connection with outside temp	Direct Inverse	Direct Inverse	-
Consumption connection with length of day	Direct Inverse	Direct Inverse	-

Capital Cost ($)	249,000
Payback Period (yr)	21

10. Comparative Overview

Woolley Building Retrofit:
Case Study A

A total of 9 cases investigated .

* Energy savings not yet materialised during this study, therefore calculation of payback period is not applicable.

** The average payback period is based on case studies which has had measurable and positive energy cost savings.

^ EUI = Energy Utilisation Index

D/I = Direct Inverse, D = Direct

Case Study	A	B	C	D	E	F	G	H	I	Average
Building Age	92	36	89	32	38	41	31	28	34	46.78
Mean energy before (kWh/month)	78153	193072	26352	52596	223998	547544	28135	131087	19095	14448
Mean energy after (kWh/month)	56769	112068	20636	48506	149381	541292	17026	125105	17333	120901.8
Change in Energy (%)	-27.03	-41.96	-21.69	-7.78	-33.31	-1.14	-39.49	-4.56	-9.23	-20.72
Mean monthly cost before ($)	6170	12304	2145	7754	31413	66248	2046	17268	1514	16318
Mean monthly cost after ($)	5185	11879	2106	8648	21727	87071	1526	16348	1577	17340.78
Change in Energy Cost (%)	-15.97	-3.45	-1.8	11.53	-30.83	31.43	-25.42	-5.32	4.14	-3.97
Gross Floor Area (m^2)	2250	2860	1890	3276	12110	14924	5558	4708	1855	5492.33
EUI^ before retrofit ($kWh/m^2/yr$)	416.82	810.09	167.31	192.66	221.97	440.26	60.75	334.12	123.5	307.5
EUI^ after retrofit ($kWh/m^2/yr$)	302.77	470.22	131.02	177.68	148.03	435.23	36.76	318.87	112.1	236.96
Relationship (energy & external temp)	D/I	None	None	D	None	D	D	None	D	-
Relationship (energy & day length)	D/I	None	None	D	None	D	D	None	D	-
Retrofit impact (energy & temp/day)	None	None	None	None	None	None	None	None	None	-
Capital Cost ($)	249,000	145,000	59,900	19,800	174,100	67,600	25,300	46,300	23,200	90,022
Payback period (yr)	21	28	128	N/A*	1.5	N/A*	4.1	4.2	N/A*	31.13**