1. TITLE: 215 ADELAIDE STREET – A NABERS UPGRADE

2. AUTHOR AND AFFILIATION:

2.1 Connan Brown

Senior Associate and ESD Manager for Norman Disney & Young Brisbane

BE (Mechanical & Space), University of Queensland, St Lucia campus

NABERS Accredited Assessor No. 40001

Green Star Accredited Professional

BERS (Residential Energy Star Rating) Accredited Assessor No. BA158

3. ABOUT THE AUTHOR:

3.1 Connan Brown:

Connan's current role focuses on providing appropriate ESD solutions to a variety of projects and clients, and amongst others is currently involved in existing building refurbishment projects; provision of Green Star Accredited Professional services for new office development and renewable energy projects. Connan returned to NDY's Brisbane office in 2008 following a four year period of service in the NDY Auckland office as a senior mechanical engineer.

Connan has a keen interest in Ecologically Sustainable Design (ESD) and energy efficiency, which started in university and has been developed through his working career.

Connan has developed both technical and negotiation skills wearing multiple hats as both the base building (novated) and tenant fitout mechanical designer with responsibilities to the developer, the main contractor and the tenant on significant projects. Connan has also co-ordinated NDY's multidisciplinary team for a number of projects notably including the Britomart Precinct which included: apartments; hotel; mixed use and three Green Star office buildings.

Connan has a developed multidisciplinary understanding of commercial building development and has a demonstrated ability to communicate at a high level with all members of a projects team including the developer, tenant, architect and main contractor.

4. ABSTRACT:

Government are increasingly looking to the building sector and particularly existing buildings as a source of carbon abatement as evidenced by the range of initiatives and legislation recently aimed at commercial buildings. Coupled with electricity cost increases and increased tenant demand for 'Green Buildings' the case for NABERS upgrades in existing buildings is strong and growing.

215 Adelaide Street is a 30,000m2 Commercial office over 29 levels in Brisbane's CBD.

The Building underwent a comprehensive building services upgrade including: chillers; cooling towers; Variable Speed Drive (VSD) control to pumping systems; VSD control to existing air handling units; high efficiency motors; car park ventilation control; Chilled Water (CHW) and Condenser Water (CW) cleaning in operation; replacement of Building Management System (BMS); smart metering system; retail CHW metering for exclusion and typical floor troffer lighting.

Currently in its first 6 months of operation detailed performance data is not available however a number of conclusions can be drawn from the design, construction and monitoring and fine tuning process.

5. INTRODUCTION

5.1 GENERAL INTRODUCTION

Energy consumption in buildings is a large drain on communities. Building power consumption makes up approximately 40 percent of the world's total energy demand and produces a correspondingly similar proportion of greenhouse gases (US DOE, 2005). Measures to improve the energy efficiency of buildings, therefore, hold tremendous opportunity. However, the potential energy cost savings alone are generally not a sufficient incentive for investing in improvement measures, unless the cost of using energy soars or regulatory or other market forces are brought to bear.

Existing buildings account for the majority of building stock and as such offer a huge potential for energy savings due to the large disparities between their current environmental performance when compared to new building stock.

Recent developments in Government carbon related policy have also seen an increased focus on energy efficiency in the commercial building sector with studies showing carbon reductions through energy efficiency improvements having a net positive economic effect on the Australian economy.

This Government focus on building energy efficiency is visibly manifested in programs such as the Green Building Fund that provided cash grants of up to 50% of the cost of building refurbishments; and the Commercial Building Disclosure (CBD) scheme that requires all commercial office buildings greater than 2000m^2 to disclose NABERS ratings at sale, lease or sub lease.

It will be interesting to see the details of the Green Building Tax Break when released and the extent to which industry feedback has been incorporated. Similarly the recently renamed Low Carbon Australia (formerly the Australian Carbon Trust) have closed an initial round of expressions of interest and are making increasingly interesting statements regarding a range of alternative funding opportunities. Other developments include the City of Melbourne 1200 Buildings program that is developing alternative ways to pay for building upgrades.

Many building owners have experienced significant increases in electricity costs and are factoring in further cost increases with full kVA billing not yet implemented in Queensland.

The case for refurbishment / retro-greening / re-lifing of existing commercial building stock is strengthening and we expect to see more of these types of projects in the coming years.

5.2 NABERS Rating Scheme

The National Australian Built Environment Rating System (NABERS) has become the most common measure of building energy/greenhouse gas performance in the Australian context, and is at the heart of a number of initiatives.

NABERS rates a building from one to five stars according to its location normalised performance over a 12 month period, with five stars representing exceptional greenhouse performance. This scheme provides market recognition and a competitive advantage for energy efficient buildings, and encourages best practice in the design, operation and maintenance of commercial buildings.

The stated goals of NABERS are:

- Reduce greenhouse gas emissions in existing buildings
- Provide market advantage for low greenhouse impact buildings
- Encourage innovation
- Encourage market best practice

There are four types of ratings available:

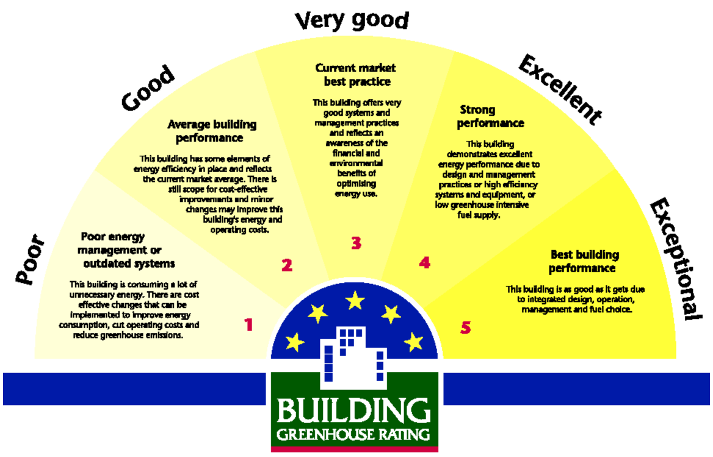
- Energy – the most common, rates Carbon intensity of building operation,
- Water – often completed in conjunction with Energy ratings, looks at Water intensity,
- Indoor Environment Quality – less common, rates indoor environment / air quality of offices,
- Waste – less common, rates waste (rubbish) intensity of offices.

There are three types of ratings available for Offices:

- Tenancy – For light & power used by tenant only
- Base Building – Central Services, HVAC, Lifts, etc
- Whole Building – Combination of the above

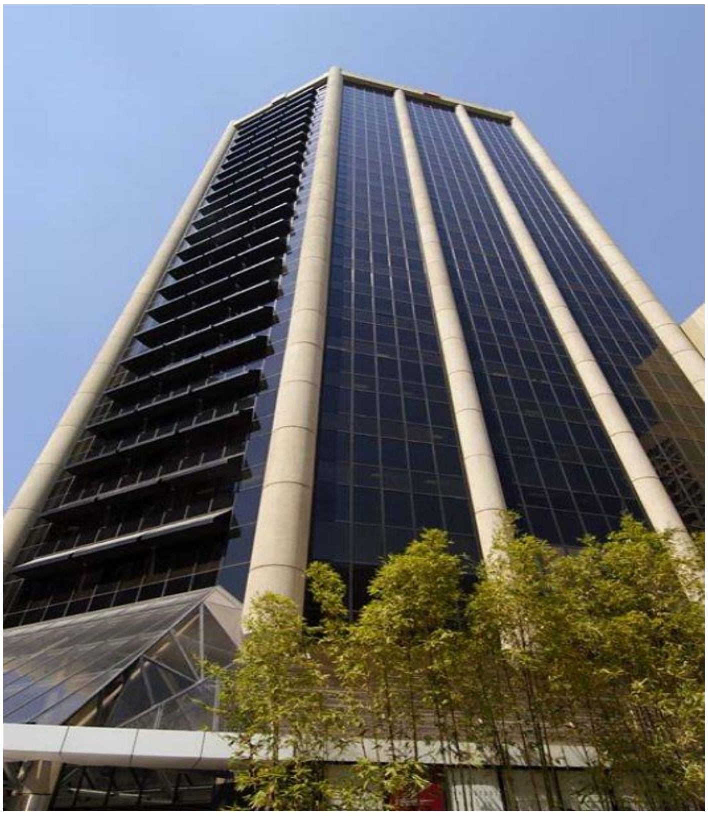
NABERS Office Base Building ratings are the most common ratings and have become the default rating for most legislative or other incentive programs.

The NABERS scheme has been recently extended to cover Hotels and Shopping centres.



Australian Building Greenhouse Rating – Star Rating Performance Indications

6. MAIN BODY: 215 ADELAIDE STREET BUILDING AND SYSTEMS UPGRADE



215 Adelaide Street was originally opened in the early 1980's as the National Mutual Building and comprises approximately 30,000m^2 of Commercial office tower block in Brisbane's CBD. The building incorporates:

1. Commercial Office, 29 level tower,
2. Heritage Office Accommodation over 4 levels,
3. Food Court,
4. Retail,
5. Three levels of underground car parking.

The building facade comprises NE, N & NW and SE, S & SW orientated curtain wall facades. The original facade design includes double glazing with integral venetian blinds and a significant portion of insulated spandrel panels.

The Building underwent a comprehensive building services upgrade including new: chillers; cooling towers; Variable Speed Drive (VSD) control to pumping systems; VSD control to existing air handling units; high efficiency motors; car park ventilation controls; Chilled Water (CHW) and Condenser Water (CW) cleaning in operation; Building Management System (BMS); smart metering system; retail CHW metering and new typical floor troffer lighting.

6.1 Existing systems and Upgrades:

Chiller Plant:

The original chiller plant comprised twin 1350kW Trane Centrifugal Chillers on R12 but with one having been changed to R134a and variable speed control during a mid-life upgrade. Low load cooling was originally provided via a 620kW reciprocating compressor machine with remote air-cooled condenser but with the remote condenser having been changed to water cooled during a mid-life upgrade.

The chiller plant was upgraded to twin Carrier 1650kW 23XRV variable speed screw chillers for base load and a single PowerPax 590kW turbocore oil-free centrifugal chiller provided for low load operation.

Detailed analysis of the tendered chiller performance data was completed using energy modelling software prior to selection of the chillers. The combination of the Carrier variable speed screw and Powerpax turbocore low load chiller offered the best modelled energy performance at an acceptable price. One significant feature noted during the modelling was the significant benefit offered by condenser water relief. The term condenser water relief refers to the efficiency benefit offered by utilising low condenser water temperatures and the extent to which it can be exploited is a function of chiller technology.

Cooling Towers:

The existing cooling tower plant comprised two equal forced draft units matched to the chillers and a single smaller forced draft unit for the tenants open condenser water loop. While the original stainless steel cooling towers appeared in fair condition from the outside their performance and capacity were less than optimal.

The cooling tower plant was upgraded to four equal sized Evapco induced draft cooling towers in two groups of two. The cooling tower system was sized for potential future growth in chilled water demand and to allow for additional tenants condenser water capacity on the floors to exceed PCA A-grade requirements.

The new cooling tower plant provides excellent redundancy, improved tenant flexibility and a solid basis for energy savings through reduced fan energy (towers) and condenser water relief (chillers).

The condenser water system did require some product specific tuning to ensure that the Carrier variable speed screws could receive the cold condenser water that they desired while protecting the packaged units on the condenser water loop and the low load chiller from low condensing temperature alarms. This was achieved by installation of bypass valves to both the tenant condenser water loop and the low load chiller.

Pumping systems:

The pumps and plantroom piping were upgraded to suit the new plant arrangement and facilitate variable speed pumping controls.

The Condenser water system incorporates constant flow variable pressure pumping to minimise energy consumption when a single pump is running (most of the year).

The Chilled water system incorporates a variable primary flow pumping strategy to minimise pumping energy and to minimise operation of the chilled water bypass valve. Chillers typically operate more efficiently when the return water temperature is higher and operation of a chilled water bypass valve (or a 3-way valve) allows 6˚C chilled water to mix with 12˚C or 14˚C return water before passing to the chillers to be cooled again.

The Tenants condenser water system was upgraded to variable speed constant pressure and all future tenant packaged units are to be fitted with solenoid valves to increase savings whenever these units are not in use.

Water treatment:

High quality water treatment systems were specified for leigonella risk mitigation and to extend the life of both the new and existing systems. Additional filtration and separation systems were installed to minimise fouling to both the chilled water and condenser water systems.

The condenser water system is served by a side stream filtration unit complete with basin scrubbers in all four cooling tower basins. The basin scrubber nozzles continuously stir up the water in the cooling tower basins to limit deposition of particulates and keep them suspended so that they can be filtered out via then side stream filter. The side stream filter pumps the condenser water through a very fine filter to remove the particulates.

Dirt separators were added to the Chilled water system to extract particulate and other contaminates that would otherwise deposit on the heat transfer surfaces of the chillers and air handling unit coils. The impact of these deposits is to reduce heat transfer efficiency of air handling unit coils and chillers (increasing system energy consumption) and is referred to as a 'fouling factor' in air conditioning design. Fouling cannot be eliminated but the effects can be managed through active systems and maintenance.

The Tenant Condenser water system is served by a dirt and air separator similar to the chilled water system but also removing fine bubbles to reduce the risk of these contaminants being pumped down through the tenants condenser water system.

The function of the dirt separators and side stream filtration is to minimise the fouling factors of the new chillers and hopefully reduce fouling over time in the existing air handling unit and tenant packaged unit coils. The modelled benefit of halving the fouling factor on the system was a saving of 2.5% of total HVAC energy usage which is significant. Secondary benefits of the filtration and separation systems include: reduced cleaning (not cleaning frequency however) required of the chiller tubes, cooling towers and strainers; reduced risk of particulates or air bubbles impacting chilled water control valves; and reduced organic load in the cooling towers thereby reducing legionella risk.

Air Handling Units:

Multizone Air Handling Units (AHU's) are provided to each office floor and serve North, South and Internal zones separately. The AHU motors were upgraded to high efficiency units with variable speed drive control implemented. Control routines include: economy cycle; night purge; duct pressure reset and supply air temperature reset.

Variable speed drive control was also added to the spill air fans with the maximum speed commissioned to achieve the acoustic requirements.

Variable Volume Boxes

The existing variable volume boxes had received a controls and actuator upgrade approximately 10 years ago and were able to be reused. However, the VAV box velocity sensors were found to be sub-standard and needed to be replaced.

Car Park Exhaust

Car park exhaust system fans were upgraded and variable speed drive control implemented to modulate fan speed on demand as required by a system of CO and NO_x sensors linked through the BMS.

Building Management System

The decision to upgrade or replace the Building Management System (BMS) was considered in detail. The upgrade of all major mechanical systems and control routines, coupled with the age of the existing system and opportunity to put the upgrade works out to an open tender pushed the decision towards replacing the BMS completely.

All existing sensors associated with the control of the upgraded systems were replaced to limit the impact of failed sensors on system operation.

Chiller Water Energy Metering

Chilled Water (CHW) energy metering was added to the retail areas to allow this portion of the chiller system energy to be excluded from the rating.

Smart metering System

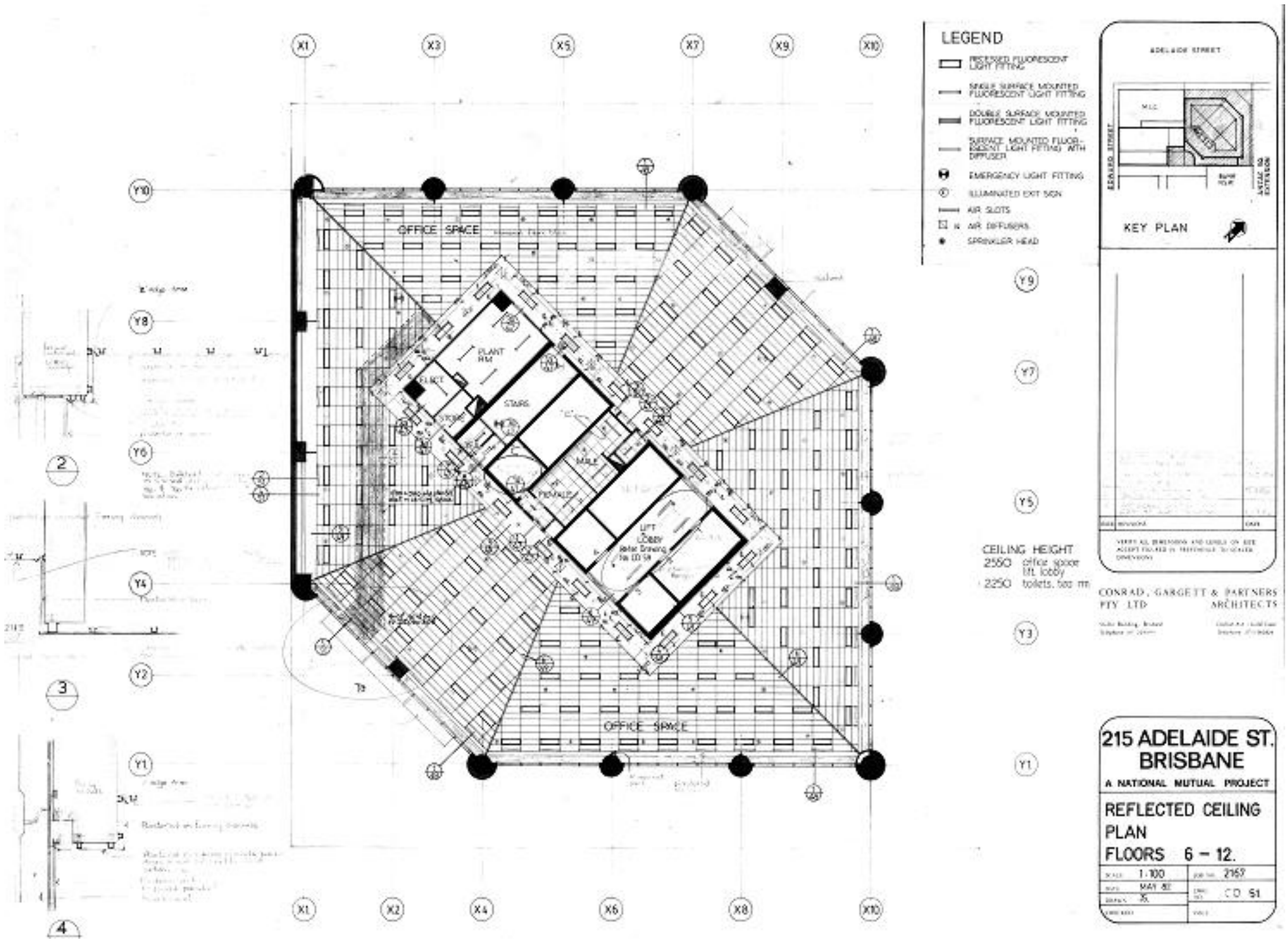
A stand alone Smart Metering system was installed to measure tenant consumption for billing as well as sub-metering the base building electricity, water and CHW Energy for tracking and monitoring.

Lighting Upgrade

The original open-plan troffer light fittings comprising twin 36W lights with mechanical ballasts and were replaced with single tube 38W troffer fittings. Both T8 and T5 solutions were considered during design, however the T8 solution proved superior by delivering a very low lighting power density (approximately $7W/m^2$) whilst still allowing a one-for-one replacement.

Modelling of the lighting upgrade indicated a 0.3 Star NABERS Base Building rating benefit but a much larger 1.5 Star NABERS Tenancy rating benefit. The base building NABERS rating benefit of the lighting upgrade was not sufficient to justify the work by itself, however it did provide multiple additional benefits, including:

- A modern lighting solution for tenants offering good uniformity and low running costs,
- Improved building power factor,
- Reduced load on the HVAC systems allowing improved tenant flexibility,
- Reduced load on the electrical submains allowing improved tenant flexibility,



Typical Floor – Reflected Ceiling Plan

6.2 Energy Modelling

To ensure that the building achieved its targeted 4.5 Star NABERS rating thermal modelling was carried out in accordance NABERS energy modelling guidelines using Trane Trace energy simulation software. The results of this modelling are set out below.

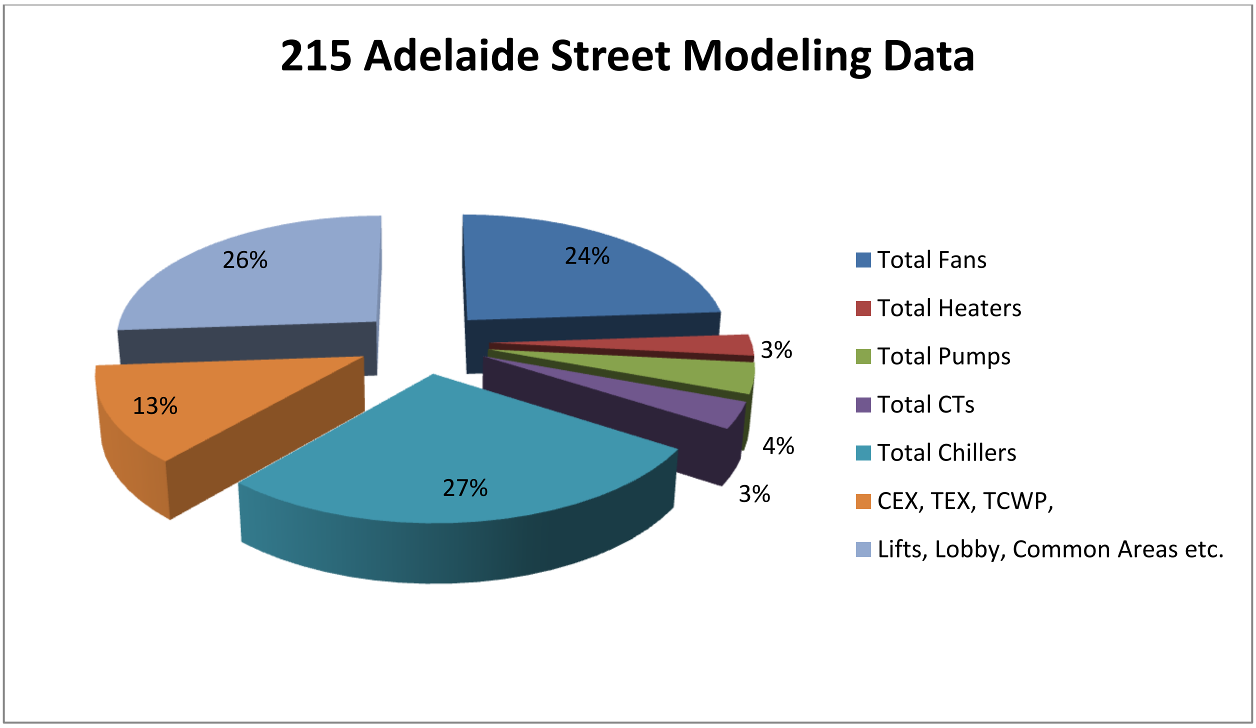


Diagram 1: Modelled Annual Base Building Energy Consumption

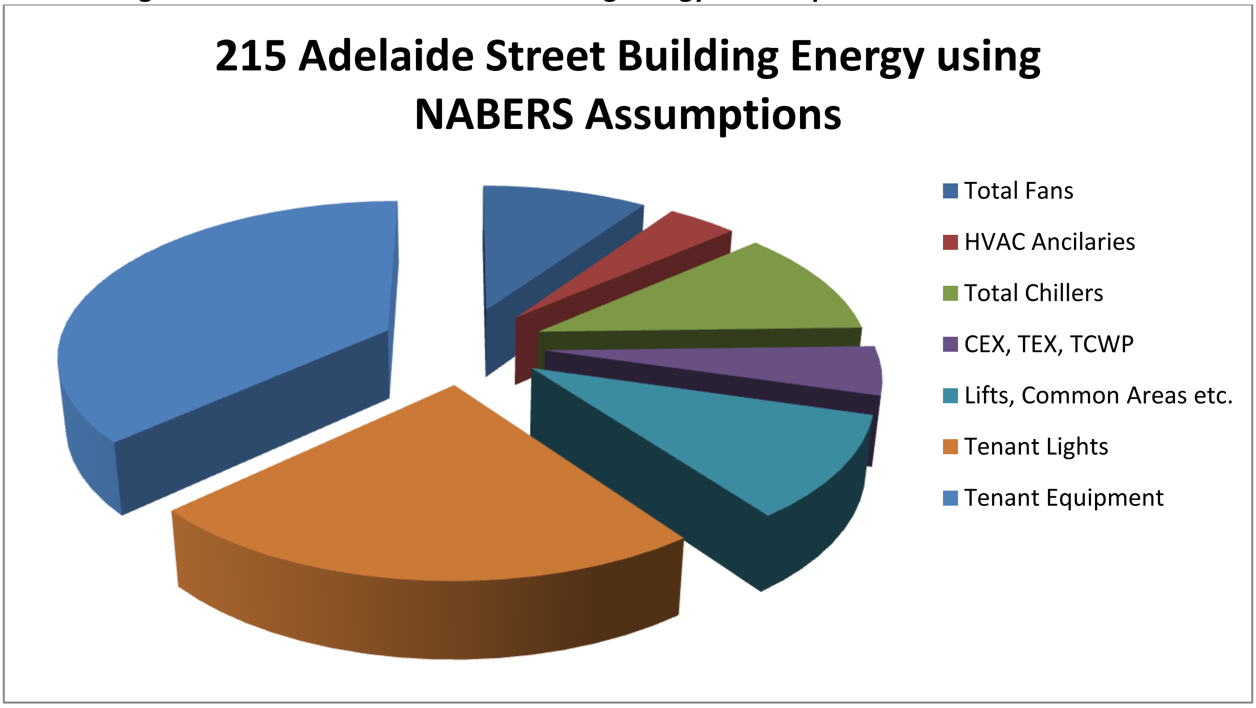


Diagram 2: Building Modelled Annual Energy Breakup

6.3 Commitment Agreement

The Commitment agreement is a key component of the project and represents a key deliverable for the building owner and manager in that it allows the building to be marketed to potential tenants using the NABERS logo and the forecast star rating, not just the existing rating.

There are a number of requirements that must be met before a formal NABERS Commitment Agreement certificate will be issued. Principle among these is the completion of an energy modelling report in accordance with very specific NABERS guidelines that assesses the forecast energy consumption best case and also a number of “off-axis” scenarios. This report must then be reviewed by an experienced NABERS and energy modelling specialist.

An off-axis modelling scenario assumes that one or more design assumption does not actually occur on-site or the control routines have failed in one or more ways.

One example of an off-axis scenario is if VAV minimum turndown is 70% in practice but a figure of 40% was used in the design. In this scenario a building with good zoning may see little impact except for increased fan energy whereas a building with poor zoning will show the fan energy increase but also a large increase in both cooling and heating energy as heating starts to fight cooling.

The purpose of the modelling report is to validate the energy model, support the Commitment Agreement and also highlight any building specific issues that need close management, for example monitoring VAV turndown and reheat in a building with a single zone per floor.

7. MAIN BODY – 215 ADELAIDE STREET CONSTRUCTION PHASE WORKS

The design documentation and energy modelling were completed by specialist building services engineering consultancy (the Engineer) and the works package was tendered to the market via a select tender on the basis of Tender design documents.

Due to timing issues the chillers were required to be pre-ordered and this enabled the building Owner and the Engineer to select the best chiller option based on technical performance rather than being swayed by the chiller package offered by the preferred Tenderer.

In a similar fashion the Tenderers were required to offer alternative prices to replace the BMS using the incumbent controls or an alternative provider. This allowed the Engineer and Facilities Manager to review the proposed controls functionality and usability and make a recommendation to the Owner to select the most appropriate controls system.

The contract was awarded to a Tier 1 Builder to deliver the project. The Builder selected mechanical and electrical trade subcontractors to deliver the works.

The chillers were installed directly into the level 4 plantroom, allowing installation via a relatively simple crane lift with a minor road closure.

Installation of the cooling towers onto level 28 was more complex and the Builders seriously considered using a helicopter for this work. In the end however the cooling towers were delivered to site via a single significant crane lift with accompanying major road closure.

Lights were installed throughout the occupied areas of the building at night with a rolling program of one or two floors being completed per night.

8. MAIN BODY – 215 ADELAIDE STREET MONITORING AND FINE TUNING

8.1 Key Players:

Key players in the fine tuning phase are the Controls Subcontractor, the Facilities Management personnel and the Engineer / energy modeller. As the physical works were completed in a satisfactory manner the key issues encountered on 215 Adelaide Street were associated with the control of the plant rather than faulty equipment.

8.1.2 Tracking to Target and Reporting:

The Facilities Manager collated utility bills; submeter readings and afterhours records on a monthly basis and forwarded these to the Engineer to track progress to target.

The Engineer would review these in light of the NABERS ratings tool and check them off against the projected energy consumption given by the energy model. A monthly report was issued indicating how the building was tracking to target.

The Facilities Manager has a key role in identifying any unusual system operation and identifying floors or units where the systems are not operating as required. In many cases the Facilities Manager was able to identify equipment requiring attention, while in other cases the problem was flagged for review by the Engineer and/or Subcontractors.

Key issues identified early on in the process include:

1. Floor air handling units were operating on un-occupied floors to control maximum humidity. This was initially a conscious decision by the facilities manager to minimise risk of sagging in the ceiling tiles. On review however, a management procedure was put in place to allow un-occupied floor air handling units to be turned off most of the time to minimise energy consumption.

2. Chiller stage up control not optimised.
3. Extensive night purge fan operation.
4. Tenants operating hours. NABERS provide a very strict protocol and assumptions for modelling to help generate consistent results in the Commitment Agreement energy modelling report. One of these assumptions is that the tenants require conditions 50 hrs per week. At 215 Adelaide Street existing tenants had arranged for different system starting times over the years. A key task in preparation for the final NABERS rating was for the Facilities Manager to keep the necessary documentation up-to-date. This included re-confirmation of required start times for tenants, keeping records from the security system for cross checking of after-hours and obtaining tenant confirmation of other specific details (including afterhours, physical vacancies and fitouts).

The first 3 or 4 months of energy consumption significantly exceeded the levels required to achieve the target causing concern and requiring detailed investigations and fine tuning.

8.1.3 Monitoring and Fine Tuning:

The Engineer assisted the Facilities Manager in setting up trends and monitoring them. When any problems appeared the affected and associated systems were studied and particulars of the problem documented. In particular what led up to the event and what else was happening at the same time with other systems was often critical in understanding the issue/s.

The Engineer was able to interrogate the BMS and trends and form an opinion as to the problem, its cause and recommended solution. This report was issued to the Builder who would advise relevant Subcontractors.

The Facilities Manager has an integral role in delivering the rating and through detailed monitoring of the systems provided critical assistance to the Engineer in identifying problems and also in monitoring the impact of implemented solutions.

The Engineer is also acutely interested in seeing the building achieve the target rating and conducted regular reviews of the BMS and trends looking for issues, changes in patterns and potential areas of excess energy consumption.

8.1.4 Key Issues

Key issues included:

a) Existing Sensors:

As the upgrade was of an existing occupied building a number of the existing sensor systems were required to be reused. The most significant of these involved the VAV box controllers and room thermostats. Prior to the upgrade the building was not experiencing significant tenant complaints, and the VAV box controllers were reused as they had been upgraded 10-15 year previously. During commissioning however the VAV box flow information was found to be unreliable, and coupled with the new low energy control routines this was causing considerable problems.

After detailed investigations by the Engineer, Builder and Subcontractors the problem was traced to the VAV box velocity sensors, the existing pitot tube sensors were found to be unreliable and prone to poor calibration. A decision was made to replace the existing sensors with modern velogrid sensors, similar to what is used in typical new office VAV systems.

b) Bypass Damper Leakage:

The existing multizone unit face and bypass dampers were causing considerable leakage past the coil and even after re-stroking the dampers the leakage was sufficient to increase the supply air temperature by up to two degrees on some floors. This issue is not readily rectified and has needed to be managed as an integral feature of the building.

c) High Fan Energy Consumption:

High fan energy consumption is a key issue for commercial office buildings, and 215 Adelaide Street suffered initially from high fan energy caused by the fans running at or near 100% during all occupied hours. Initial investigations identified the velocity sensors and bypass dampers being responsible for this by driving up the duct pressure and supply air temperature respectively.

Unfortunately the bypass dampers and velocity sensor issues consumed significant time and delayed the discovery of other controls tuning issues.

Further investigation revealed that the system pressure reset (and fan energy reduction) was not being effectively utilised. This was due to the supply air temperature reset and internal/south zone mixing damper controls effectively pre-empting it by suppling warmer air and keeping the VAV boxes open.

Supply air temperature reset is considered important to minimise system reheat and can be very effective in reducing chiller plant loads particularly if the chiller system can be shut down completely during economy cycle operation. In 215 Adelaide Street the significant retail component means that the chiller plant cooling call never really stops during occupied hours.

d) Chiller Loading / Unloading:

Chiller loading and unloading control is critical and initially was not initially operating optimally at 215 Adelaide Street.

The chiller stage up control was set up to be based on chiller amps. Due to the characteristics of the chiller the chiller amps does not accurately reflect the loading of the machine when the condenser water return temperature is less than design. Due to the significant benefits of ambient relief the chiller might be delivering 100% cooling but only drawing 75% of it's maximum amps.

The solution was to change the step up control to reflect the chiller capacity based on the compressor speed as per the manufacturers directions.

e) Smart Metering:

The Smart metering system interface was programmed to meet the requirements of the operators, rather than being modified from some existing proprietary user interface software. In theory this offered the potential for a fully customised system, however in practice the custom user interface took a long time to be programmed and was not fully operational until partway through the first 12 months of operation.

9: RESULTS:

At the time of writing the system had not been operational for a sufficient length of to enable representative results to be provided.

One immediate result was an improvement of the building power factor as quoted on the utility bills from less than 0.8 to 0.93, effectively alleviating the need for significant expenditure on power factor correction equipment.

10: CONCLUSIONS:

Chiller ambient relief is a powerful energy saving feature that has only recently become a significant feature on smaller chillers. Consideration of the condenser water system and careful review of chiller performance characteristics should deliver significant energy savings. Chillers should not be compared on full load efficiency alone. The procurement planning for energy upgrade projects should consider how chillers are to be purchased so as to manage capital costs while delivering the optimum energy solution.

Cooling towers are usually located at the top of buildings and this means that installation is typically complex and costly (while the cooling towers themselves are relatively inexpensive). Considering the benefits of ambient relief and the cost and complexity of upgrading cooling towers, equipment selections should tend towards larger units rather than smaller ones.

From experience with 215 Adelaide St, it is clear is that fine tuning is critical in achieving low energy in operation and to approach the energy efficiency potential of the installed equipment. It would also appear that close involvement and communication between the Engineer and the Facilities Manager in the tuning process is necessary.

As noted by the building owner at practical completion 'now the building has to deliver the rating' – the real work in monitoring and fine tuning the building operation has really just begun.

11. ACKNOWLEDGEMENTS:

Authors would like to acknowledge the efforts of the following parties involved in delivering this project:

Facilities Manager and Owners Representative:	Jones Lang LaSalle
Project Manager:	John Outhwaite and Associates
Builder:	Built.
Mechanical Services:	James L. Williams
Electrical Services:	KLM Group

13. REFERENCES AND/OR BIBLIOGRAPHY:

NABERS (the National Australian Built Environment Rating System) is a national initiative managed by the NSW Department of Environment, Climate Change and Water. For more information about NABERS please refer to the NABERS website: http://www.nabers.com.au/