

Case Study

Commercial Building Energy Efficiency
Retrofit – 4 Mort Street, Canberra

In 2010, 4 Mort St, Canberra (Figure 1) was upgraded to significantly improve its energy performance. The retrofit was performed with the dual constraints of a limited budget and the building remaining occupied during the upgrade. This Case Study covers the key factors that enabled this 45 year old commercial office building to achieve a 2.5 star increase to 4.5 star NABERS Energy Rating, including the pathway taken and the technologies used.

Figure 1: Street view of 4 Mort Street, Canberra



Background

The building:

- ▶ constructed in 1966 and owned by Trafalgar Platinum Fund
- ▶ 5 stories with net lettable area (NLA) of 5,400m²
- ▶ 2 star NABERS Energy Rating, as assessed
- ▶ Commonwealth tenants, with single retail tenant leasing part of ground floor, Commonwealth leases were set to expire
- ▶ existing HVAC reaching end of operational life, unreliable and expensive to maintain
- ▶ difficulty maintaining occupant comfort using existing HVAC system.

In order to retain capital asset value the building owner decided to upgrade the building to target a 4.5 star NABERS Energy Rating.

The upgrade was also done in the context of:

- ▶ requirements to meet the Energy Efficiency in Government Operations Policy requirements for Australian Government tenants¹, and the ACT Environmental Leasing Policy requirements for Territory Government tenants²
- ▶ the impending Australian Government Commercial Building Disclosure (CBD) regulations requiring an energy performance rating to be disclosed when advertising for lease or sale³
- ▶ minimal disruption to business was also required so that tenants could continue to occupy the building throughout the upgrade
- ▶ a limited budget of \$1 million, supplemented by \$500,000 from the now closed Green Building Fund⁴.

Results

- ▶ Improvement from 2 to 4.5 star NABERS Energy Rating, and aiming to achieve a 5 star NABERS Energy Rating in 2013.
- ▶ Improved systems monitoring through the installation of a modern building management system (BMS).
- ▶ Annual energy cost saving of \$120,000.
- ▶ Increase in asset value estimated at \$1.4 million.
- ▶ 70% reduction in annual greenhouse gas emissions equating to 786 tonnes CO₂-e.

Figure 2: Chilled water buffer vessel at 4 Mort Street, Canberra



¹ www.climatechange.gov.au/en/government/initiatives/eego

² www.economicdevelopment.act.gov.au/__data/assets/pdf_file/0005/245813/ACT_Environmental_Leasing_Policy.pdf

³ www.cbd.gov.au/

⁴ www.ausindustry.gov.au/programs/innovation-rd/gbf/

Retrofit Pathway

The retrofit involved the following key steps:

1. a Level 2 Energy Audit
2. a building simulation
3. recommended upgrades of the HVAC plant and lighting systems in the common areas
4. commissioning and fine tuning of the HVAC system.

Figure 3: Air Handling Unit at 4 Mort Street, Canberra



1. The Energy Audit

An energy audit is required to establish a thorough understanding of the energy consumption of an existing building. This allows for a more targeted approach to HVAC and building energy efficiency upgrades, and helps to identify the most cost-effective measures. These may range from the optimisation of the existing systems to replacement of systems with more energy efficient alternatives.

Energy audits are typically carried out in accordance with AS/NZS 3598 2000, which details three levels of energy auditing, Level 1 is the simplest up to Level 3 as the most detailed. For typical office type buildings, a Level 2 audit will generally suffice with some data-logging carried out where the existing systems do not have sufficient sub-metering for analysis.

The energy end use breakdown for 4 Mort Street revealed that the HVAC systems accounted for 90% of base building energy consumption. This included 11% of the electricity consumption which could not be allocated to an identified end use - a clear indicator of energy wastage. Most likely this was associated with

after-hours operation of the HVAC system servicing the entire building for the sole benefit of the small retail tenant on the ground floor.

The following recommendations were made in order of potential impact.

- ▶ Changing the energy source for space heating from electricity to natural gas. Natural gas has a much lower greenhouse coefficient of 0.24 KgCO₂-e/kWh than electricity supplied from the grid which is currently 1.06 KgCO₂-e/kWh in the ACT.
- ▶ The installation of a modern building management system (BMS) to effectively control and monitor the new HVAC system, using energy smart control strategies and monitoring features. More detail on the BMS installation is included in a companion case study.
- ▶ The reinstatement of the economy cycle to air handling systems to provide free cooling when favourable (cool) ambient conditions prevail. The lack of or inefficient operation of the economy cycle is a common cause of poor energy efficiency in HVAC systems, with the potential to decrease energy performance by as much as 20%.
- ▶ The installation of motorised dampers at each floor to enable selective and economic use of air-conditioning after hours.
- ▶ Conversion of the existing constant volume air distribution system to a semi variable air volume (VAV) system modulated at branch ducts, allowing variable rates of air flow depending on air-conditioning requirements.
- ▶ Replacement of old reciprocating type R22 chiller with a modern high-efficiency centrifugal machine with magnetic bearings and adiabatic cooling pads⁵.
- ▶ Reducing energy consumed by the tenant's supplementary condenser water loop by installing motorised valves to the air conditioners and a variable speed drive to the condenser water pump.
- ▶ HVAC system rezoning to improve occupant comfort and reduce conflict between the operation of cooling and heating systems.
- ▶ The installation of separate split system HVAC units for the retail tenancy, so that the main HVAC plant does not condition the whole building in order to satisfy the requirements of the retail tenancy on Saturdays. This would include the installation of electricity sub-metering to monitor and/or exclude the energy consumption of the retail tenancy HVAC.
- ▶ To replace inefficient dichroic type down-lights with light emitting diode (LED) light fittings, as well as the installation of low cost motion sensor automatic lighting control devices to all base building areas including lift lobbies, toilets, car park, entrance lobby and external lighting.

⁵ As part of Australia's commitment to phase-out ozone depleting refrigerants, R22 imports will be banned from 2016. Owners of such chillers are now facing increased costs for replenishing this refrigerant, and with the introduction of the carbon price, synthetic greenhouse gases will also attract additional costs. www.environment.gov.au/atmosphere/ozone/

A significant obstacle for the project was the limited budget available for the retrofit. The findings from the Energy Audit were provided as supporting evidence for the award of a \$500,000 grant from the GBF. The award of this grant for 4 Mort St made a significant impact to the financial viability of this project.

2. The Building Simulation

A building simulation was undertaken to compare the energy performance of the building under different HVAC design options. This information enabled the proper selection of HVAC equipment taking into account important factors such as part load efficiency, duty/standby capacity requirements and the use of energy smart control strategies for staging the equipment.

After the equipment selections were made, the model was used to predict the energy performance of the building after the proposed upgrade work. The model was then used to identify any additional areas of occupant discomfort, allowing the design engineers to readjust airflow rates through the existing ductwork systems.

The model's results were also useful for tracking the building's NABERS energy performance for the 12 month period following the upgrade work. The thermal energy demands of a building are seasonal in nature and also depend on factors such as after-hours operation of the HVAC systems. The model predictions enabled monthly targets to be set for electricity and gas consumption to ensure greenhouse gas emissions were within the necessary limits to deliver the targeted 4.5 star NABERS Energy Rating.

3. Targeted Upgrades

The design team considered all the options identified in the energy audit and engineered the solutions with due consideration to staging requirements necessary to minimise disruption to the tenants.

The final design included the following:

- ▶ specification of the BMS incorporating energy smart control functions to include optimum start and stop, chilled water reset, economy cycle, night purge which uses cooler ambient air at night time to pre-cool the space, and VAV control (including feedback from CO₂ and duct velocity sensors)
- ▶ the inclusion of BMS monitoring features such as the energy consumption of the chiller, all electric motors (through variable speed drives), mechanical switch board, and thermal energy for chilled and heated water systems
- ▶ the inclusion of key BMS controls and sensors, to enable back up control strategies to be adopted if the designed strategy presented unforeseen challenges during the commissioning and fine tuning stages

- ▶ optimised selection for chiller and boiler plant efficiency, taking into account part load performance. A magnetic bearing centrifugal chiller with an air-cooled condenser incorporating adiabatic pads was selected for cooling
- ▶ condensing type boilers were selected for heating
- ▶ fuel-switching for space heating from electricity to gas
- ▶ design for air handling and distribution system efficiency, including the conversion of the existing constant volume system to a semi VAV system with air flow regulation through the motorisation of existing volume control dampers and the modulation of supply air fans through variable speed drives. The need for wasteful re-heating was eliminated through the regulation of air flows to zones using CO₂ sensors and duct velocity probes
- ▶ the installation of thermal insulation above BCA requirements, in general R values higher than 1.8m² K/W were applied to all new pipe work and existing accessible air distribution ducts. Thermal insulation was also applied to all pipeline components such as pumps, valves, flanges and strainers, which are not traditionally insulated (see Figure 4).

Figure 4: Insulated heating hot water pump and pipe work at 4 Mort Street.



The design engineers faced practical challenges including restrictive ceiling void spaces, which made access and system design more difficult. Conventional methods for implementing some of the measures listed above, including the installation of new VAV terminal units and diffusers were not practical. Innovative means had to be designed and carefully installed to achieve the necessary gains in efficiency. Further details are provided in four technical factsheets that accompany this case study.

4. Fine tuning, Monitoring and Commissioning

Buildings and their HVAC systems need thorough commissioning and fine tuning in order to deliver optimal performance and occupant comfort. These stages are typically overlooked for a number of reasons, including:

- ▶ the project installation phase runs over time and as a result the commissioning stage is reduced
- ▶ the main contractors do not appreciate the value of commissioning or the time it takes
- ▶ inadequate specification of the commissioning process by the design engineers.

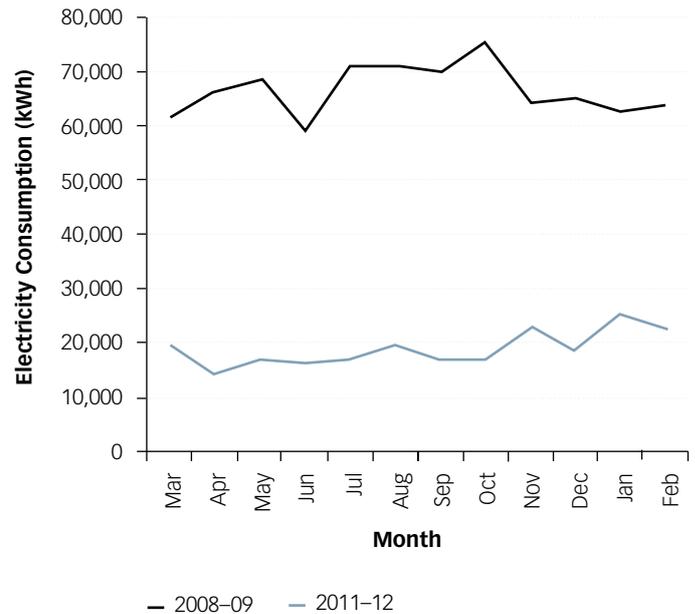
Good commissioning, monitoring and fine tuning all contributed significantly to the success achieved at 4 Mort Street. Attention to detail included the calibration of pitot type velocity sensors installed in somewhat non-ideal conditions (given space restrictions) on existing ductwork. Monitoring included remote access to the BMS by the Contractor and GHD staff. Strict protocols on changes were implemented including requirements for documentation of any changes to control strategies and operating parameters before any adjustments were made that could have an impact on energy consumption.

Results

The services upgrade work was successfully completed in November 2010 and the building achieved an accredited 4.5 star NABERS Energy Rating for the base building in January 2012. The building’s energy performance continues to be monitored, and with further fine tuning and improvements to control strategies, the building owner is aiming to achieve a 5 star NABERS Energy Rating in 2013.

Electricity consumption has significantly been reduced (Figure 5), resulting in annual energy cost savings of \$120,000 and a 70% reduction in annual greenhouse gas emissions equating to 786 tonnes CO₂-e.

Figure 5: Electricity consumption pre and post retrofit



In addition to the energy savings, plant reliability has increased together with an improvement in occupant comfort due to enhanced zoning arrangements and better control. Most notably, however, asset value is estimated to have increased by \$1.4M.

Considering the capital costs incurred were \$1.5 million and assuming a saving of \$120,000 per annum, the payback period would be 12.5 years. However, this does not take into account the increase in asset value and tenancy returns post retrofit. The building’s increase in asset value of \$1.4 million effectively means that the payback period would be as little as 1 year. Furthermore, if you were to take into account any associated increases in rental returns, it is likely the resulting costs would be negative. This is an aspect of efficiency retrofits that is often overlooked. The largest financial gains are those associated with the increase in asset value and tenancy rental returns following such upgrades.

Project Team

Part of the success of this project was attributed to the project team and its atypical structure:

- ▶ a design consultant was appointed with a broad range of expertise including ecologically sustainable development (ESD), energy auditing, building simulation and system design, ensuring consistency, continuity and accountability throughout the project⁶
- ▶ the design consultant in this case was also the ESD consultant. Where this is not the case, the ESD consultant should work very closely with the design engineers and take joint responsibility for the ESD outcomes, including the 12 month monitoring phase

⁶ Where this is not viable and different consultants are appointed for different aspects of the analysis and design, it is important that there is a clear communication and designation of responsibilities.

- ▶ in appointing a project manager the decision was made to pre-select potential local contractors with proven track records and then to negotiate a price, rather than go out to tender. This ensured relevant and proven experience rather than least cost
- ▶ since the nature of the upgrade was mainly HVAC services, it was important for the selected project manager to have mechanical expertise with project management capability, rather than being a specialist management contractor.

The Team and their responsibilities:

- ▶ GHD Canberra: Engineering consultancy services covering energy audit, building simulation, detail design and documentation, monitoring and NABERS Energy Rating
- ▶ Waldren Construction: Project management, mechanical and electrical services
- ▶ Allstaff Air-Conditioning: Mechanical sub-contractor
- ▶ MDM Electrical Services: BMS and electrical services sub-contractor.

Conclusion

4 Mort Street Canberra was in a situation common to many aging commercial buildings. The building was performing poorly (estimated at 2 stars NABERS Energy), the existing HVAC system was nearing the end of its operational life (unreliable and expensive to maintain), energy prices were increasing, and some of the government tenancy leases were due to expire. In order to retain the building's capital asset value it was necessary for the energy performance of the base building to reach a minimum 4.5 star NABERS Energy Rating in line with the Australian and State and Territory Government leasing policies. Faced with a limited budget for capital expenditure and a requirement that the existing tenants remain in situ throughout the improvements, the task of upgrading the building was not a small one.

What is clear from this case study is that the financial incentives are not only associated with savings in energy consumption, but also include increases in asset value and rental returns.

HVAC HESS

The Heating, Ventilation and Air-Conditioning High Efficiency Systems Strategy (HVAC HESS) is a ten-year strategy under the National Strategy on Energy Efficiency (NSEE) that aims to drive long-term improvements in energy efficiency of HVAC systems Australia wide. Under the Energy Efficiency Working Group (E2WG), the Commercial Buildings Committee (CBC) manages the implementation of the HVAC Strategy. The CBC is comprised of representatives from Australian, State and Territory Governments.

The Strategy takes a whole of life perspective in targeting HVAC efficiency improvement, encompassing the design, manufacture, installation, commissioning, operation and maintenance stages of the HVAC lifecycle. The Strategy consists of a number of complementary measures that fall under the three broad initiatives - People, Practices and Systems. This case study of the 4 Mort Street, Canberra retrofit specifically relates to Practices.

The following accompanying factsheets relating to the retrofit of 4 Mort Street, Canberra can be found on the DCCEE website at:

www.climatechange.gov.au/government/initiatives/hvac-hess:

- ▶ Chiller Efficiency
- ▶ Boiler Efficiency
- ▶ Building Management Systems
- ▶ Air Handling Units.

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