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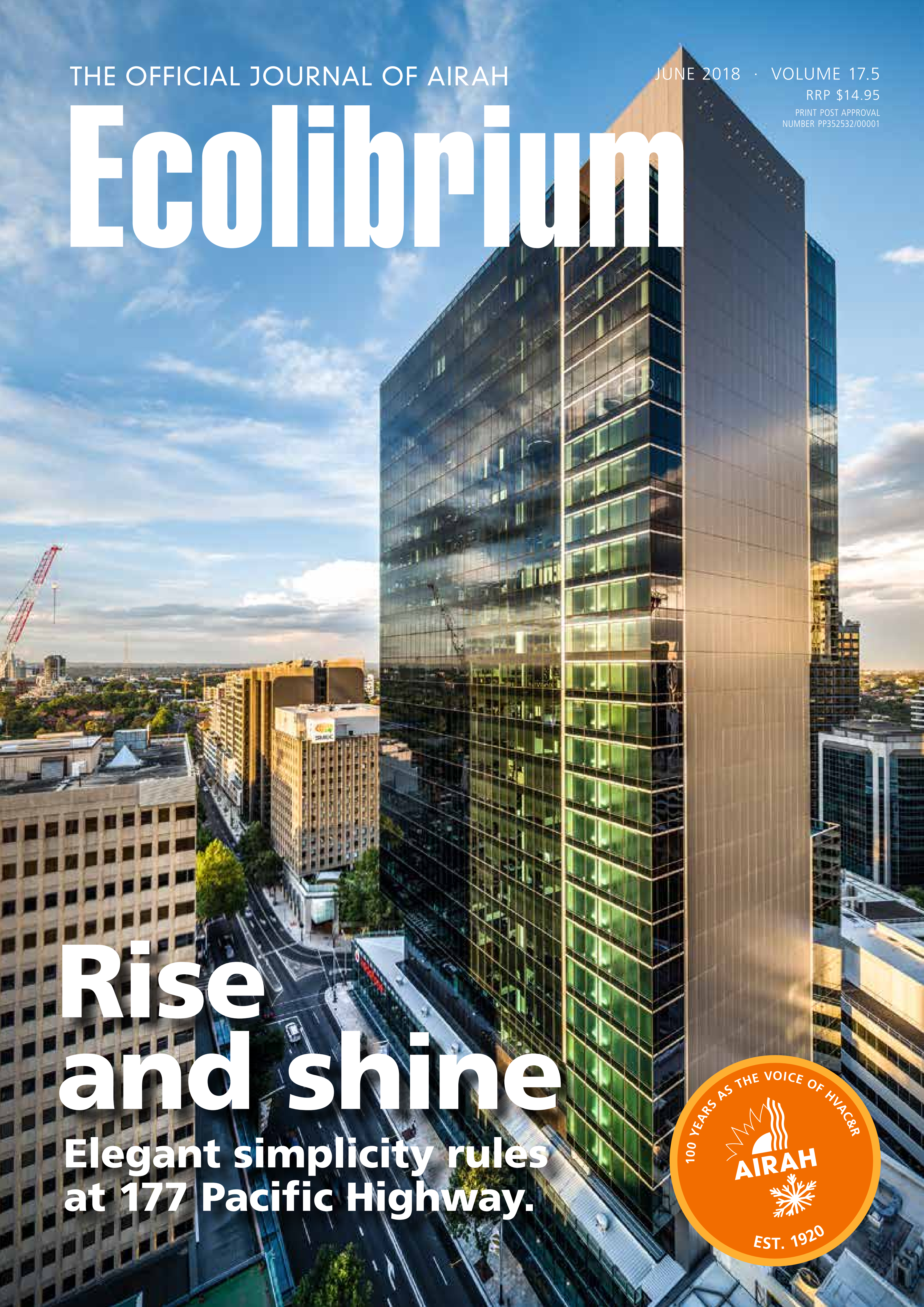

Rise and shine

Elegant simplicity rules at 177 Pacific Highway.

100 YEARS AS THE VOICE OF HVAC&R
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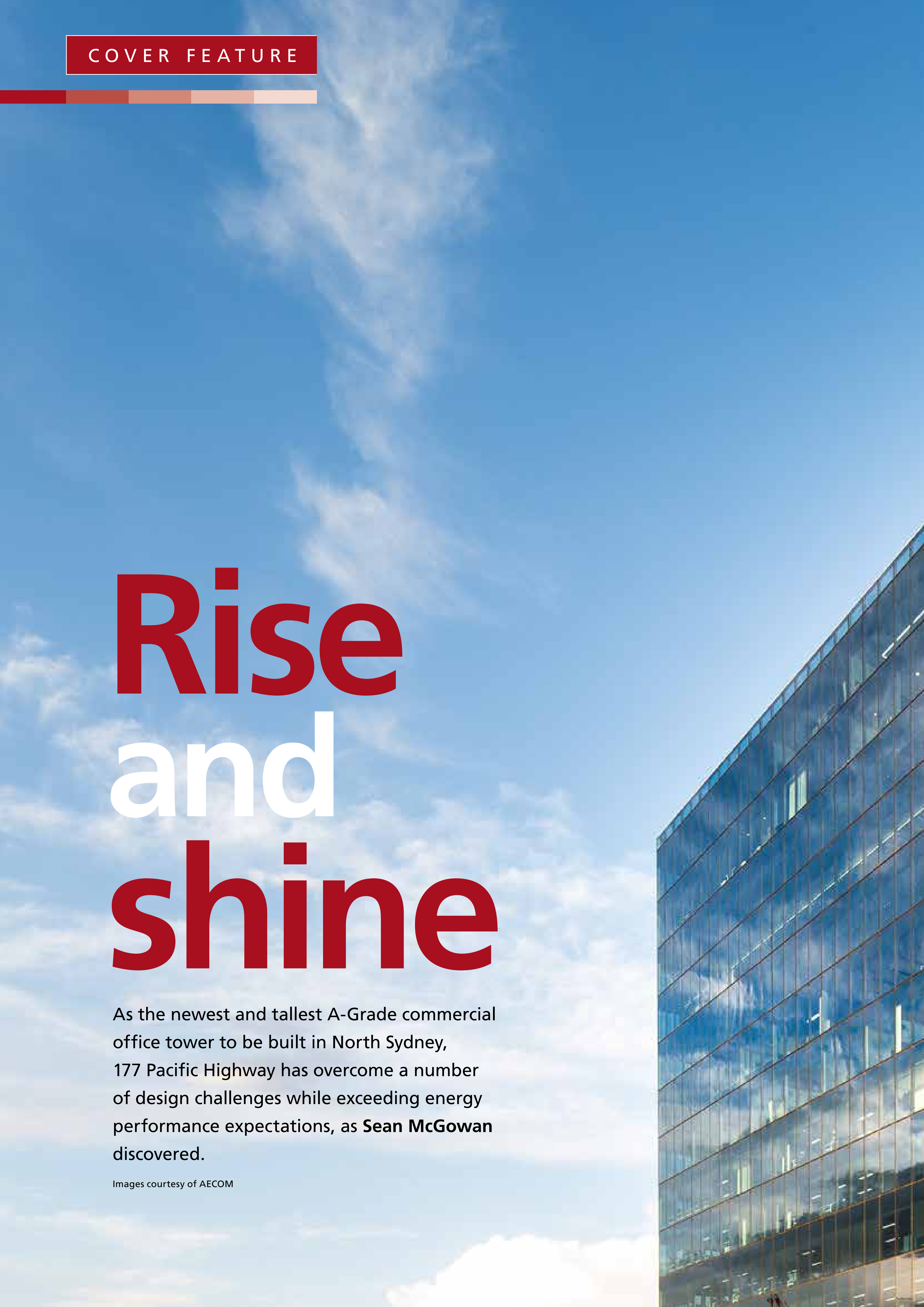

Rise and shine

As the newest and tallest A-Grade commercial office tower to be built in North Sydney, 177 Pacific Highway has overcome a number of design challenges while exceeding energy performance expectations, as **Sean McGowan** discovered.

Images courtesy of AECOM


Image supplied by NDY.

At 31 storeys, the 195m building reaches the suburb's maximum height limit.

Sometimes, the most expensive or complex option does not always result in the best performance. And so it goes at North Sydney's newest and tallest addition, 177 Pacific Highway.

The building has been designed by architectural firm Bates Smart, developed by Leighton Properties for owner Suntec Real Estate Investment Trust (Suntec REIT) and built by CPB Contractors, with AECOM providing services engineering. It features a deceptively simple design, which supports the flexibility demanded of modern workplaces by enabling collaboration and integration.

Indeed, simplicity in design and construction was the mantra adopted throughout the project – from the building's raised architectural form that creates a new public space at its base, to an energy-efficient design that has it achieve a 5.5 star NABERS Energy rating without the use of green power.

At 31 storeys, 177 Pacific Highway reaches the suburb's maximum height limit of 195m while limiting overshadowing and solar access of surrounding properties and spaces.

"Overshadowing prohibitions have effectively prevented new high-rises in North Sydney for nearly two decades," says Philip Vivian, director at Bates Smart. "Much of the debate about tall buildings has been around their height but the concern should be focused on public amenity rather than height. Our aim for 177 was to demonstrate that tall buildings can be built in dense urban environments without impacting on the public amenity of the city."

Any overshadowing created by the building was minimised by large cut-outs to the eastern façade, and is also compensated by the creation of a publicly accessible "wintergarden" plaza. The plaza benefits from solar heat gain to warm it in winter (supplemented with hydronic heating) and uses convection cooling in summer to maintain comfortable conditions.

But it's the simplified approach to the mechanical services design and resulting energy performance that might turn heads.

HIGH VALUE

AECOM was engaged by Leighton Properties and then novated to CPB Contractors to provide mechanical, electrical (including communications and security), hydraulic and fire protection design services, as well as fire engineering, acoustic and ESD engineering consulting services for 177 Pacific Highway in the third quarter of 2013.

"The HVAC and mechanical services brief was to provide elements typical of a high-quality commercial office property while maintaining a high level of occupant comfort, energy efficiency, operational reliability and environmental sustainability – all at a low delivery cost point," says Tim Dunn, principal engineer – sustainability for AECOM. "Having floor layout system flexibility to more easily accommodate fitout designs was also a brief driver."

The mechanical services brief demanded a response to an internal equipment load of 15W/m², a tenant supplementary loop capacity of 25W/m², a minimum of four after-hours operation zones per floor, and tenant supplementary outside air of 0.3l/s/m².

Typical office temperature set-points of 22.5±1.5°C were required, while a conditioned entrance lobby required slightly relaxed temperature control more befitting of a transient space.

Additionally, improved indoor air quality was required through 100 per cent increase in outside air ventilation over AS/NZS1668.2-2012, combined with demand-controlled ventilation (DCV) using CO_2 levels to optimise ventilation requirements and manage energy consumption.

According to Dunn, the project's sustainability targets included 5 star Green Star Office Design v3, 5 Star Green Star Office As Built v3, and a 5 star NABERS Energy base building (commitment agreement without green power) rating.

"Our immediate design challenge was how to provide such a level of service," Dunn says, "combined with the desired efficiency while managing project costs."

STARRY OUTCOMES

177 Pacific Highway reached practical completion on August 1, 2016. It reached full occupancy by the end of that year.

The building's HVAC systems performed well post-occupancy, with no major issues encountered during the defects liability period (DLP). With minor tuning, temperatures were maintained during occupancy and the energy performance of the HVAC system exceeded target expectations.

Monthly energy monitoring of the building performance was undertaken for a year following occupation. It found that energy consumption of major HVAC system components aligned with, or was less than, modelled targets.

"A reasonable reduction in energy consumption compared to the simulation targets was seen for the AHU and RA fans, which is testament to the sound delivery by Fredon Air and product performance of the plug fan, built up AHUs," says AECOM's Tim Dunn.

Monthly building performance review workshops led by CPB were also completed. These included Fredon, Alerton (BMCS contractor), the building manager CBRE, Leighton Properties, AECOM and other trades when appropriate.

These workshops were considered indispensible in reviewing energy performance, obtaining occupant feedback (CBRE, CPB and Leighton Properties are all occupants), and to determine any appropriate tuning activities to carry out for maintaining the target outcomes and optimise performance for occupants.

The high energy efficiency of the HVAC plant has supported the building achieving a certified NABERS Energy base building rating of 5.5 stars – a half star above target.

Dunn says a sizable buffer existed above the 5.5 star rating, such that the overall base building energy consumption and greenhouse gas emissions were over 14 per cent less than that of a 5.5 star rating. For the current NABERS Energy rating period, an actual energy intensity of 236MJ/m² per annum was achieved.

"From our review of data for NABERS Energy base building certified developments, 177 Pacific Highway ranks very highly," says Dunn. "It appears to outperform other recent developments – and all without green power, chilled beams or cogen," says Dunn.

"By utilising straightforward design strategies and pushing these to the limit, this project has maximised performance and exceeded expectations at a low price point."

Facilities Manager CBRE is optimistic that with further tuning during 2018, a 6 star NABERS Energy rating may be achieved.

The project has utilised straightforward design strategies and pushed them to the limit.


High levels of system energy efficiency have been realised without the use of chilled beams.

LOW COST, HIGH PERFORMANCE

AECOM's mechanical and ESD teams completed detailed analysis during the concept design stage of the 177 Pacific Highway project to evaluate the appropriate HVAC design strategies to take forward. This included simulation modelling to set system design performance targets.

This revealed that high levels of system energy efficiency could be realised by using a variable-air-volume (VAV) arrangement, without resorting to chilled beams as either a full solution or in a hybrid arrangement.

"For many contemporary buildings hybrid systems are looked to for the pursuit of high energy performance," says Dunn. "However, by targeting increased air-handling system efficiencies it is possible to achieve high levels of performance using a VAV arrangement."

Analysis for the project showed a key design requirement to sufficiently minimise operational energy consumption for the VAV design strategy was to reduce air-handling system pressures to a maximum of 850Pa total static. This included all supply and return pressure losses – both internal and external – coupled with high-efficiency fans and motors.

AECOM's analysis considered whole-building integrated design approaches to balance heating and cooling loads, operational performance goals such as 5-star NABERS Energy, and drivers from Green Star such as occupant thermal comfort and daylight performance.

Dunn says the analysis was carried out to establish design requirements in support of a NABERS Energy base building rated level of 5 stars plus a further 25 per cent energy reduction for a buffer over the 5-star target.

With a VAV system approach selected, AECOM set about overcoming the challenges associated with spatial

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constraints. These were further complicated by the loss of net lettable area (NLA) on some levels where building setback (i.e., the cut-outs to the eastern façade) was required to meet overshadowing conditions applied by North Sydney Council.

"Pressure then mounted to reduce plant rooms and risers to gain back NLA," says Dunn.

To reduce riser sizes and air-handling plant volume, a split air-handling strategy was employed, with two air-handling unit (AHU) groups serving the major halves of the office space from two separate air-handling plant locations at Level 3 and the roof plant at Level 31.

"This allowed risers to be constrained to air volumes for a smaller portion of the building, as opposed to the whole building per riser," says Dunn. "In this way, we were able to claw back some NLA on each floor."

Further NLA was gained by progressively reducing the duct risers to suit the required air volumes.

"This was achieved through an innovative design by both CPB and the structural consultant (Arcadis) of the core wing walls and upstand beams to support the office slabs adjacent to the risers," says John Mills, senior design manager for CPB.

"By adjusting the projection of these concrete riser wing walls, the core/risers were reduced and therefore more NLA was gained on the majority of office floors."

THE CONTRACTOR

In 2014, mechanical services design contractor Fredon Air was engaged to the project by CPB Contractors and began to work closely with AECOM on the mechanical services design.

With Fredon taking "design and construct" responsibility for the mechanical services, achievement of the HVAC design brief objectives and operational performance now fell more heavily to them.

At this time, Fredon was asked to provide pricing for a number of HVAC concepts including the VAV system design, and an alternative hybrid system utilising active chilled beams on the perimeter.

FANS OF THEIR WORK

According to Tim Dunn from AECOM, some issues were encountered during the commissioning process with the dual-fan AHUs. These are designed to operate with a single fan to serve low-flow/load requirements, or operate both fans for higher flow/load.

"Switching between single and dual-fan operating modes was found to cause some issues," he says.

"Some flow reversal through the non-operating fan was found to occur under certain conditions, leading to this fan turning backward. The variable-frequency drive was found to not be able to start the associated motor when the fan was turning backward."

To negate the issues encountered when starting the fans, staging steps and processes were implemented.

The latter system proved to be significantly more expensive than the former. No guarantees could be established that the system would perform any better than the VAV system from an energy-efficiency or temperature-control perspective. The VAV arrangement was therefore settled as the final design strategy.

"This type of air conditioning system (VAV) is a simpler system to control compared to other concepts, and presents lower maintenance costs for the client," says Zois Kotsis, construction manager for Fredon Air. "Spatially, however, it is a challenging format."

Fredon was able to offer further efficiencies by using a higher temperature difference on the condenser water side (8°C split) compared to the original concept design of 5.5°C.

This resulted in slightly larger cooling towers. But as an overall system combined with chiller performance, it operates in a more energy-efficient manner.

"This also enables further cooling tower fan turndown during normal operation," says Kotsis, "while taking advantage of the increased water surface area in the towers, and the resultant energy savings." says Kotsis.

UPS AND DOWNS

The building's HVAC design utilises a chilled and heating water thermal plant connected with central air-handling plant that is split into three groups to serve Ground to Level 2 (from Level 3), Levels 4 to 17 (from Level 3) and Levels 18 to 30 (from Level 31).

The VAV system features separate AHU thermal zones per façade orientation (excluding a small south zone on some floors), as well as two central zones. AHUs utilise AC motor plug fans with dual fan/motor assemblies for large units.

"Serving each façade and centre thermal zone individually allows a single supply temperature from each AHU to be provided," says Dunn. "It also removed the need for reheat of supply air for another zone with a different load profile, maximising thermal efficiency."

This means reheat equipment is not required, avoiding the associated energy penalty.

LESSONS FROM THE CONSULTANT

AECOM's principal engineer – sustainability, Tim Dunn, shares some of the lessons that can be taken from the design of 177 Pacific Highway's mechanical services systems.

1. A high level of HVAC system energy efficiency can be achieved with an all-air VAV system when carefully designed and constructed. If sufficient space is available for such a system selection, more expensive systems such as chilled beams do not need to be included.
2. Early involvement of the ESD team was integral to the achievements of the project. Engagement of an ESD engineer is sometimes left until after major services and other design decisions have already been taken.

   However, the ESD engineer has a strong role to play in driving and coordinating design of high-performance buildings to make sure integrated decisions are implemented.
3. Close collaboration and good working relationships with the client, architect and contractor team are vital. This allows for more flexibility in the consideration of design options, leading to well integrated design solutions and successful delivery.

   Any issues developed during the course of the project are able to be resolved more quickly. For example, the architect Bates Smart communicated very effectively with AECOM and worked through issues such as the floor setback changes due to council overshadowing restrictions.

The main air-handling systems were designed and selected to keep system pressures very low, with total air-loop static pressures below 850Pa on average. This included all AHU supply system losses (internal, external and dirty filter allowances) and return-air fan losses.

The chilled water plant, located on Level 3, incorporates three water-cooled variable-speed screw compressor chillers in a parallel reticulation arrangement. Dedicated variable primary-only chilled water pumps and dedicated condenser water pumps are part of the system. Heat rejection is achieved via induced draft cooling towers located on the roof.

"The three chillers were selected to provide sufficient redundancy per the Property Council of Australia requirements," says Dunn. "They include a small chiller for optimal continued operation at low loads."

Dunn says the units selected for this project feature excellent part and high-load performance (Coefficient of Performance of 5.99 and an Integrated Part Load Value of 10.95) and have contributed significantly to the project's overall energy efficiency.

A supply-air temperature of approximately 10.5°C was selected to reduce required air volumes and minimise AHU plant, ductwork spatial requirements and riser sizes. Combined with the low system pressure and high-efficiency plug fans, the air-handling design fan power requirements are very low.

"Variable-air volume, coupled with a static-pressure reset control strategy, allowed significant reductions in fan power and operational energy at lower than peak space loads that occur at most times," Dunn says.

The heating water plant incorporates four gas-fired hot water boilers that have been split into pairs at the air-handling plant locations on Level 3 and Level 31 to reduce water volume and pipe runs.

"This configuration allows heating systems to reach temperature sooner and reduces piping heat losses, providing a more efficient system than a single-point plant location," Dunn says.

As the location of the boilers on Level 3 meant there was no access to the roof for discharge, Fredon Air designed dilution fans for the flues to ensure horizontal discharge was compliant.

LESSONS FROM THE MECHANICAL CONTRACTOR

Fredon Air's construction manager, Zois Kotsis, shares some of important lessons from the 177 Pacific Highway project.

1. Work as a team with CPB and all the consultants – instead of the traditional "taking sides" scenario.
2. Early involvement on the job ensures minimum requirements are implemented in the building design for proposed mechanical systems.
3. Pay extra attention to the manufacturer/installation details and equipment selection to save time on site.
4. Try to minimise the assumptions and to lean the design (closer to actual required capacities) to achieve the maximum efficiency possible on plant selection and reduce the energy loss on oversized plants.
5. Smart control and design strategies with real-time optimisation control loops are an integral part of realising high operational performance.

TEMPERATE SPACE

177 Pacific Highway features a unique podium level comprising a three-storey open atrium space above the ground entrance lobby surrounding Levels 1 and 2, which are enclosed from the atrium space.

The HVAC design response here provides for a temperate space with slightly relaxed temperature control to provide a transitional entry from outside to the conditioned lift lobby enclosed at the core of the building. It includes a combination of underfloor supply air for mechanical ventilation and cooling. Heating is achieved via an in-slab hot water radiant system to the centre zone, and perimeter zone hot water trench heating.

Dunn says this space also operates as mixed mode ventilation, with a natural ventilation mode comprising low-level operable louvres and high-level roof ventilators.

"The roof ventilators are also motorised to allow a forced ventilation mode for free cooling where appropriate," he says.

In conditioned cooling mode, cool supply air is provided throughout the space at low level. Convection-driven air movement assists to drive heat to the top of the space, which is relieved through the roof ventilators. Heat gains from occupants and the retail tenancy in this space (as well as any solar heat gain) drive this natural convection.

"Dynamic thermal simulation modelling was used to validate system sizing in support of the desired internal space temperatures," adds Dunn. "Additionally, the modelling was used to narrow in on appropriate control set points at which to transition between the different ventilation modes."

Other spaces such as the main switch room, building manager's office, loading dock office and lift motor room are served by small packaged air conditioning systems.

"This choice was made to avoid heating and chilled water reticulation costs from the main systems," he says, "and allow operation at any time without requiring the main thermal plant to be operated."

PROGRESSIVE COMMISSIONING

AECOM undertook witness testing and commissioning data review, with the independent commissioning agent from WSP also witnessing various commissioning activities and undertaking reviews.

Interestingly, this project was air balanced prior to the plant rooms being completed. The VAVs were calibrated without the AHUs being available by utilising a temporary fan supplying air to the individual floors.

"This proactive solution was proposed by Fredon based on the construction programme of the building and floors, and the fact that half of the floors are being served by the top plant room on Level 31," says Kotsis.

"These temporary fans were installed on Level 18 – the last level served by the top plant – and provided immediate access to supply air for balancing of the floors instead of waiting for the main AHUs to come online," Dunn says. "This resulted in progressive commissioning in lieu of a one-hit process through a shorter period of time."

To allow progressive commissioning to occur, duct risers were designed to suit the process and provide enough access to the shafts and fans for balancing. Additionally, Fredon Air had to ensure enough air was available on the floor for the fan's intake, in a safe manner. ■

PROJECT AT A GLANCE

The personnel

- **Architect:** Bates Smart
- **Builder:** CPB Contractors
- **Client:** Suntec REIT
- **Developer:** Leighton Properties
- **ESD engineer:** AECOM
- **Facilities manager:** CBRE
- **Independent commissioning agent:** WSP
- **Mechanical services design contractor:** Fredon Air
- **Mechanical services engineer:** AECOM
- **Structural engineer:** Arcadis (formerly Hyder Consulting)

The equipment

- **AHUs:** Fan Coil Sales
- **Air-cooled split units:** Mitsubishi Electric
- **BMS:** Alerton Australia
- **Boilers:** Simons (ICI Caldaie)
- **Chillers:** Carrier
- **Controls:** Alerton Australia
- **Control valves:** Siemens
- **Cooling towers:** Metro Cooling Towers
- **Dampers:** Airfoil
- **Fans:** Fantech
- **Grilles:** Airfoil
- **Pumps:** Masterflow Solutions
- **Refrigerant recovery system:** JAVAC
- **Sensors:** Alerton Australia, Siemens
- **VAV boxes:** Celmec
- **Water-cooled PAC units:** Dunnair

(Source: AECOM and Fredon Air)