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Identifying common issues in mid-tier HVAC maintenance: Commercial Offices, Aged Care, Hotels and Shopping Centre

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Abstract

This report outlines to what extent the issues identified in the Better Ways to Work Report extend to sectors beyond mid-tier commercial office buildings. This report considers common issues across commercial office buildings, aged care, hotels and shopping centres.

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BETTER WAYS TO WORK

IDENTIFYING COMMON ISSUES IN MID-TIER HVAC MAINTENANCE: COMMERCIAL OFFICES, AGED CARE, HOTELS AND SHOPPING CENTRES

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ABOUT THIS REPORT

Title: Identifying common issues in mid-tier HVAC maintenance: Commercial Offices, Aged Care, Hotels and Shopping Centres.

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EXECUTIVE SUMMARY

This report presents findings from a study exploring to what extent the issues identified in the *Better Ways to Work* survey extend to sectors beyond mid-tier commercial office buildings. Whilst the initial survey targeted building service contractors working in the mid-tier office sector, many of the identified issues will likely have similarities with other sectors.

To assess the similarities and differences between sectors, three major activities were undertaken:

1. A review of relevant literature for aged care, hotels and shopping centres
2. Interviews with sector experts and professionals
3. Focus groups with HVAC and facilities management professionals in these sectors

The review of literature identified key questions to be explored through interviews, and the focus groups served to ground-truth the insights resulting from the interviews with the on-ground technicians and managers.

As a general conclusion, HVAC contractors who had experience across sectors reported that the major issues identified through the *Better Ways to Work* survey (lowest cost contracting, skills and training shortcomings for contractors and facilities managers, and lack of clear standards for appropriate maintenance) were common in each of the sectors. Interviews with stakeholders and facilities managers working in the various sectors did identify differences in terms of building stock, HVAC equipment and organisational drivers or barriers, however these did not appear to result in substantially different HVAC maintenance practices.

A summary of the key findings for each building type is provided below.

AGED CARE

- HVAC in Residential Aged Care facilities are typically simple systems, with widespread use of domestic and light commercial systems, such as split-systems and packaged AC units. Consequently, maintenance tasks are simpler and the cost to replace is lower, meaning run-to-fail is not uncommon.
- The aged care sector has a unique regulatory environment, which is substantially different to other sectors. There is a requirement to maintain comfortable internal conditions, and there is therefore very little tolerance for poorly performing systems or discomfort for residents. This does not necessarily translate in to best practice maintenance regimes, largely due to the widespread use of simple and low-cost systems.

- The sector is price conscious, and is particularly sensitive to ongoing maintenance costs. Increased maintenance costs to maintain operation is a key trigger for upgrade or replacement, whilst energy costs or energy efficiency appears to be a secondary consideration.
- Whilst asset management was reportedly unsophisticated, aged care providers appear to be on an upward trajectory in terms of their asset management and maintenance, with many respondents identifying moving to improved systems, largely as a result of regulatory changes in NSW.

HOTELS

- Hotels are similar to commercial offices in many respects. For example, hotels appear to have similar building stock, HVAC equipment and maintenance practices. Whilst many premium hotels are likely to be undertaking best practice maintenance, it appears that a mid-tier sector with poorer maintenance regimes also exists in the hotels space. Similar to the office sector, this will largely be related to age, location and ownership profile, as well as the star rating of the hotel.
- The issue of split incentives does not appear to be a major issue within hotels, although the organisational split between capital and operating expenditure does appear to exist, and impact on the quality of HVAC systems and maintenance.
- Although guest satisfaction is clearly impacted by HVAC performance, this does not appear to translate into best-practice maintenance for much of the hotels sector. In many cases, HVAC is not given much though or investment, until a major failure or breakdown. Reactive maintenance dominates.

SHOPPING CENTRES

- Shopping centres appear to be similar to offices in some respects, with important differences. Many of the portfolio owners in the premium office space are also owners of shopping centres, and therefore maintenance practices and energy performance is expected to be relatively similar. It is likely that there is a mid-tier in shopping centres, largely related to ownership profile, although this is likely to be much smaller proportion than in the office space due to the relatively centralised ownership.
- There is an interesting relationship between anchor tenants and centre owners, as there is a clear split incentive at work. Anchor tenants are typically responsible for their own maintenance, with owners responsible for any replacement or upgrade works, meaning that reducing ongoing operational costs is not likely to be a strong motivation for upgrades. There is also an additional incentive for tenants to undertake appropriate maintenance (to ensure that any breakdowns are not caused by inappropriate maintenance), however this does not necessarily translate into best-practice maintenance.
- There was evidence of best practice amongst supermarkets. The major chains were highlighted as being concerned with management and maintenance of HVAC, largely due to the substantial refrigeration in their stores, and the energy use and cost implications of this.
- Shopping centres were identified as ‘compliance heavy’, and very concerned with ensuring all obligations were met and documented, to maintain insurance coverage in public spaces.

CONTENTS

1. INTRODUCTION

The University of Wollongong was engaged through 2020-21 by the Department of Industry, Science, Energy and Resources (DISER) to develop, administer and analyse an industry survey looking at Heating, Ventilation and Air Conditioning (HVAC) management and maintenance practices in mid-tier office buildings.

The project was developed to progress commitments under the *Addendum to the Trajectory for Low Energy Buildings – Existing Buildings.*

HVAC is the largest end-use of energy in commercial buildings. The aim of the project was to better understand how energy productivity can be improved in HVAC systems in the mid-tier commercial building office sector.

The *Better Ways to Work (BWW)* survey was the largest national survey of facilities managers, HVAC contractors and associated design and systems specialists undertaken to date.[1] It provided a substantial new empirical data source for understanding how the HVAC repair and maintenance workforce engages with buildings and technologies, with building owners and tenants, with governance authorities and regulators, and with each other through formal institutions, and through informal, everyday working relationships.

This report details findings from a follow-on project designed to explore to what extent the findings from the *Better Ways to Work* survey extend to sectors beyond mid-tier commercial office buildings. Whilst the initial survey targeted building service contractors working in the mid-tier office sector, many of the identified issues will likely have similarities with other sectors.

In consultation with the DISER project team, aged-care buildings, hotels, and shopping centers were selected as the sectors for further investigations. The current report details the findings of this investigation. It is structured as follows:

- Section 2 presents a summary of the main findings from the initial survey
- Section 3 presents the methodology used to explore relevance to the identified building sectors
- Sections 4-6 present targeted literature reviews and analysis of data collected through interviews and focus groups for each sector under consideration. The review focused on understanding the ownership, management and tenancy structures, typical HVAC configurations, maintenance practices and energy performance/efficiency policies and programs for each sector.

1. Full details and analysis of the initial survey, as well as a review of previous work in the mid-tier sector, and a discussion of policy implications from the survey results, can be found in Carr, C., Stanes, E., Daly, M., Daly, D. & McGuirk, P. (2021) *Better Ways to Work: HVAC management, repair and maintenance in the mid-tier commercial office sector.* Final report, March 2021.

2. SUMMARY OF BETTER WAYS TO WORK SURVEY RESULTS

The following section presents a summary of the main findings from the *Better Ways to Work* survey.[2] The survey report presented the results according to three key areas, namely: People, Buildings and Systems, and Maintenances Practices. The current report provides analysis of the relevance of these findings to the other identified commercial building sectors.

Key empirical findings include:

PEOPLE

- Participants in the initial survey were most commonly HVAC contractors (53.8%), Facilities Managers (FMs) (23.0%) and engineer/system designers or consultants (16.2%). It is anticipated that many contractors and system designers will work across sectors, whilst FMs may be more sector specific.
- SMEs were the most common enterprise type for contractors (46.8%) and engineers/systems designers (50.8%), whereas facilities managers were predominantly (37.9%) from multi-national enterprises, with strong representation (27.5%) from national businesses or enterprises. This has implications for continuing professional development and knowledge dissemination.
- Contractors are trade-qualified (87%) and experienced (73.8% >11 years).
- Facilities managers are variably qualified (trade/diploma/degree) but with high rates (69%) of on-job experience reported as qualification. A high rate of trade qualifications (45%) indicates a career pathway from contractor to facilities manager.
- Responses indicated strong representation from members of professional associations, which may reflect recruitment channels and confirms anecdotal evidence of difficulty accessing non-members.
- Contractors and facilities managers are both effective conduits to building owners but require different training and information dissemination strategies.
- Facilities managers were most commonly engaged by owners (59.8%), with 23.8% reporting being engaged by tenants. Contractor were engaged equally often by owners and facility mangers (40.4% and 40.5% respectively).

2. Carr et al. (2021).

BUILDINGS AND SYSTEMS

- As reported in prior studies, the mid-tier sector is heterogenous and segmented. Multiple tenants per floor was the most common tenancy type observed, and there was a low penetration of owner-occupied buildings. This means tenants, commonly multiple different tenants, are key players in mid-tier upgrade and retrofits.
- All HVAC system types were commonly encountered; central plant only was slightly more common than mix of central/splits, which may indicate substantial 'patching' over old and under-performing systems. There was a relatively high penetration of split systems only. System type was influenced by state and geographical context.
- Many (42.7%) report that most buildings have original HVAC system with no upgrade since installation, and few (22.3%) report that most buildings have been fully retrofitted.
- Participants were asked to identify the proportion of buildings they work in that have a functional BMS. The mean response of 56.6% confirms anecdotal knowledge indicating that there is significant scope for improvement in the control and monitoring capacity of Australia's mid-tier building stock. A high proportion of respondents (47%) reported that less than half the buildings they work on have a functional BMS.

MAINTENANCE PRACTICES

- Equipment suppliers and informal knowledge sharing networks (experienced colleagues) are a key source of information, at almost double the rate of more formal continuing professional development (CPD) training. This has significant implications for the delivery of energy efficiency training and information dissemination.
- Cost is overwhelmingly the deciding factor when choosing between repair and replacement of systems and components. However, there is a slight mismatch between contractors and facilities managers when asked about what matters when engaging/wining work. Facilities managers report lifecycle cost as more important than upfront cost, whereas contractors see upfront cost as more important.
- Preventative maintenance is a greater than expected activity in the sector. However, the prevalence of maintenance, and explicitly planned and preventative maintenance, as the 'number one action that could be taken to make HVAC systems perform better' suggests that there remains an unmet need for additional maintenance work.
- Responding to comfort complaints were the most frequent reactive maintenance task, and the most common fault types were also amenable to simple fixes – filters and thermostats.

The survey findings highlighted the need for a mix of policy approaches to lift the energy performance of mid-tier office buildings. These may include empowering stakeholders through better training, information and capacity building; carefully targeted incentive programs that recognise geographical disparities in building stock, ownership profiles and workforce characteristics; and lifting energy performance through a range of regulatory pathways.

Additional follow up research to the *Better Ways to Work* survey, conducted concurrently with work described in this report, explored in greater depth the key issues impacting on HVAC maintenance quality.[3] The nine most significant issues, with a short description, are captured in Table 1.

3. Daly, M. Carr, C., Santala, I., Daly, D., Stanes, E. & McGuirk, P. (2021) *Mapping decision-making and opportunities for improving energy efficiency across the mid-tier HVAC maintenance lifecycle*. Final report, December 2021. ISBN:978-1-74128-356-3.

Table 1. Key issues impacting HVAC maintenance quality in mid-tier commercial office sector

1	Maintenance decisions about whether to patch repair or upgrade a system component are commonly made because of the upfront cost implications on annual budgets, rather than overall lifecycle cost and ongoing system performance implications. *This can have adverse impacts on maintenance and upgrade decisions.*
2	Preventative maintenance contracts lack detail regarding expected standards of HVAC maintenance expectations. *This can lead to differing interpretations by contractors and clients about what standard of maintenance has been agreed to, and that HVAC contractors are working to meet.*
3	The budget for a new HVAC system installation or major upgrade is determined before any input from HVAC professionals, which can rule out the best solutions. *This can involve trade-offs between minimising system lifecycle costs and minimising upfront costs to fit to the pre-determined budget.*
4	Job performance is judged on a short timeframe, while the impacts of maintenance decisions can play out over a long timeframe *Both HVAC contractors and facilities managers have their performance judged over a short timeframe (e.g. meeting yearly budgets, meeting quoted repair costs) while the impacts of sub-standard maintenance can take many years to become obvious (e.g. shortened lifespan of equipment from 30 years to 20 years). Because of this, short term fixes are often prioritised.*
5	Facilities managers and/or property managers are primarily held accountable to meeting or exceeding annual budget targets, rather than optimising building performance over the lifecycle of the building. *This can have adverse impacts on maintenance and upgrade decisions.*
6	There is a lack of consequences in the industry for malpractice, whether in installation or maintenance of HVAC. *This means that poor practices and/or operators are more likely to occur.*
7	There is often a lack of checking and oversight of the quality and completeness of installation and maintenance work. *This means that obvious issues or mistakes are not noticed and rectified.*
8	The very competitive, cost driven nature of the preventative maintenance market. *The market for preventative maintenance contracts is very competitive and price driven, meaning preventative maintenance is often delivered as a lowest cost service. We want to understand the implications of this for HVAC maintenance.*
9	In many buildings, maintenance is the responsibility of tenants, while replacements/upgrades are the responsibility of building owners. Owners are often keen to avoid major system upgrade or replacement works. *This creates conflicting priorities about maintenance and upgrade works.*

3. METHODOLOGY

This report summarises information collected through three main activities, namely:

- A review of relevant literature for each commercial building sector
- Interviews with sector experts and professionals
- Focus groups with HVAC and facilities management professionals in these sectors

The detail of each of these activities are as follows:

1. A review of literature regarding ownership profiles, energy and HVAC regulation and maintenance practices for each commercial building sector. Very limited peer-reviewed academic literature was identified, therefore the summary relied heavily on industry and government reports.
2. Interviews with sector experts and professionals. Twelve interviews were undertaken, exploring specifics of the commercial building sectors under investigation, including:
   a. Building stock (age, size, quality of construction)
   b. Ownership profile and turnover
   c. Tenant profile and turnover
   d. Commercial environment (re: leasing, investment factors etc)
   e. Typical HVAC stock
   f. Management of HVAC service quality (i.e. who makes comfort complaints, who scopes work and engages contractors)

Key questions identified during the literature review were also explored, and the extent to which issues identified during the *Better Ways to Work* survey were prevalent in the sectors was explored. A summary of interview participants is provided in Table 2.

Table 2. Summary of interview participants

ROLE DESCRIPTION	ORGANISATION	AGED CARE	HOTELS	SHOPPING CENTRES
Asset manager	Large aged care provider	X		
Asset manager	Regional aged care provider	X		
Asset manager	Regional aged care provider	X		
Facility manager	Large aged care provider	X		
Facility manager	Large aged care provider	X		
HVAC technician	National service company	X		
Facility manager	Australia Institute of Hotel Engineering representative, and premium hotel engineer		X	
Facility manager	National management company		X	X
HVAC technician	National service company			X
HVAC technician	National service company			X
HVAC technician	National service company	X	X	X
HVAC engineer	Controls SME		X	X

3. Focus groups were held with respondents to the original *Better Ways to Work* survey who had indicated that they i) were willing to participate in further research, and ii) had experience in one or more of the sectors. Two focus groups were held to ground-truth the findings from the interviews amongst those working on these building types, with discussions focused on similarities and differences between the sectors in the areas discussed in the interviews, and the prevalence of the key barriers to better maintenance in these sectors. A summary of the focus group attendees is provided in Table 3.

Table 3. Summary of focus group participants.

ROLE DESCRIPTION	ORGANISATION	AGED CARE	HOTELS	SHOPPING CENTRES
	Focus Group 1			
Asset manager	Aged care provider	X		
HVAC technician	Regional SME	X	X	X
HVAC technician	Urban SME	X	X	X
HVAC technician	National service company		X	X
	Focus Group 2			
HVAC technician	Now working in state government FM	X	X	X
HVAC technician	Retired	X	X	X
HVAC technician	Regional SME	X	X	X
HVAC technician	Urban SME	X		X

The following section summarises the findings according to each commercial building sector. The results of the literature review are presented, along with key questions outstanding following the review of the literature. A summary of the results from the interviews and focus groups is then presented. For this work, all participants have been de-identified, and direct quotes have not been provided. Rather, the findings present a concise summary of the relevant similarities and differences between each sector and the mid-tier commercial office sectors. Finally, a summary of the implications of this work in terms of policy responses is presented.

4. AGED CARE

AGED CARE KEY POINTS

- Typically, HVAC systems in Residential Aged Care facilities are relatively simple systems in comparison with centralised chilled water systems common in other sectors. The sector predominantly uses domestic and light commercial systems, such as split-systems and packaged AC units. Newer facilities seem to heavily favour VRF units. Consequently, maintenance tasks are simpler and, for split-systems, the cost to replace is lower. Anecdotally many providers simply run these domestic systems to failure with only minimal scheduled maintenance, and then replace.
- The aged care sector has a unique regulatory environment, which is substantially different to other sectors. There is a requirement to maintain comfortable internal conditions, and there is therefore very little tolerance for poorly performing systems or discomfort for residents. This does not necessarily translate into best practice maintenance regimes, largely due to the widespread use of simple and low-cost systems.
- The sector is price conscious, and is particularly sensitive to ongoing maintenance costs. Increased maintenance costs to maintain operation is a key trigger for upgrade or replacement, whilst energy costs or energy efficiency appears to be a secondary consideration.
- Aged care providers appear to be on an upward trajectory in terms of the sophistication of their asset management and maintenance, with many respondents identifying moving to improved systems, largely as a result of regulatory changes.
- While aged care providers are typically both the owner and operator (and often developer) of their RAC facilities, there are still commonly management and decision-making splits between the development and operational arms of the providers, leading to upfront costs of HVAC equipment being prioritised over lifecycle maintenance costs.
- Notwithstanding these unique features, HVAC technicians who had experience across sectors reported that the major issues identified through the *Better Ways to Work* survey, such as lowest cost contracting, skill and training shortcoming for technicians and FMs, and lack of clear standards for appropriate maintenance, were also common in this sector.

OWNERSHIP AND MANAGEMENT STRUCTURES

In their study of aged care services, the Australian Institute of Health and Welfare[4] found that 80 per cent of older people accessed some form of government-funded aged care before death. While most of this care consists of home support services, permanent and respite residential aged care (RAC) is estimated to make up 23% of all the aged care services in Australia.[5] According to the Australian Department of Health operational report there were:

- 2,722 RAC facilities in Australia in 2020
- Operating a total of 217,145 residential places
- Providing care for 244,363 permanent residents and 66,873 respite clients throughout 2019 and 2020.

The Productivity Commission[6] estimated that, in 2020, close to 80% of the RAC facilities consisted of more than 61 operational places, and the location of operational places varied from:

- 70.6% in major cities
- 21.2% in inner regional areas
- 7.6% in outer regional areas
- 0.5% in remote areas.

To provide Australian Government-funded aged care, providers must be approved under the *Aged Care Act 1997*. The Department of Health service list[7] shows that RAC services are provided across three sectors: not-for-profit, private for-profit and government. While the not-for-profit sector has traditionally been the most significant RAC provider in Australia, recent de-regulation, funding guarantees and user contribution mechanisms have led to an increase in the private ownership of facilities.[8] In 30 June 2020, the Department of Health[9] presented the operational residential care places as divided between:

- 23.2% Religious organisations
- 18.7% Charitable organisations
- 13.1% Community-based organisations
- 41.2% For-profit organisations
- 3.3% State/Territory government
- 0.5% Local government.

The distribution between private, government and not-for-profit facilities varies across state and territories. Here a defining factor is that major cities tend to attract more privately owned facilities, while smaller jurisdictions and remote areas are relying mostly on not-for-profits.[10] For example, in 2020, Victoria had the largest proportion of for-profit (53%) and government (9%) operated residential care places and the lowest proportion of not-for-profit operated places (38%).[11] Tasmania and Northern Territory were shown to depend mainly on not-for-profits who operate up to 83% and 76% of the RAC places respectively.[12]

4. Australian Institute of Health and Welfare (2012) *Residential Aged Care in Australia 2010-11: A Statistical Overview.*

5. Department of Health (DOH) (2020a) *2019–20 Report on the Operation of the Aged Care Act 1997.* https://gen-agedcaredata.gov.au/www_aihwgen/media/ROACA/20366-Health-Report-on-the-Operation-of-the-Aged-Care-Act-2019%e2%80%932020-accessible.pdf Retrieved April 1, 2021.

6. Productivity Commission (2021) Report on Government Services 2021. Chapter 14, aged care services report. https://gen-agedcaredata.gov.au/www_aihwgen/media/Productivity-Commission/rogs-2021-partf-section14-aged-care-services.pdf Retrieved April 23, 2021.

7. Department of Health (DOH) (2020b) *Services and places in aged care. Aged Care Service List*. https://www.gen-agedcaredata.gov.au/Resources/Access-data/2020/October/Aged-care-service-list-30-June-2020 Retrieved April 23, 2021.

8. Henderson, J. & Willis, E. (2020) The Marketisation of Aged Care: The Impact of Aged Care Reform in Australia. In Collyer, F. & Willis, K. (eds) *Navigating Private and Public Healthcare*. Singapore: Palgrave Macmillan, pp. 249-267.

9. DOH (2020a)

10. Australian Institute of Health and Welfare (2012)

11 DOH (2020a)

12. DOH (2020a)

From the 845 RAC providers (DOH 2020a, b), the five largest are:

- The Uniting Church in Australia Property Trust (135 facilities)
- Southern Cross Care (81 facilities)
- DPG Services Pty Ltd (77 facilities)
- Bupa Aged Care Australia Pty Ltd (72 facilities)
- Estia Investments Pty Ltd (69 facilities).

Other large organisations include Regis Group Pty Ltd (65 facilities), Japara Aged Care Services Pty Ltd (51 facilities) and Allity Pty Ltd (44 facilities). Based on the Department of Health service list,[13] the 7 largest organisations are responsible for 20% of all the RAC facilities.

Many of the large organisations provide promises of comfort and sustainability targets as part of their marketing:

- The Uniting Church: *"Our rooms offer you all the comforts of home you'd expect, with options to suit your needs and budget."* mentioning air-conditioning
- Southern Cross Care: *"Achieve 10% reduction of our total consumption of resource use by 2021 (based on the baseline) across the board (electricity, gas and water) on a per bed basis."*

It is common for the owners of aged care facilities to also manage their own properties, as evidenced in statements in public-facing documentation such as:

- The Uniting Church: *"According to The Basis of Union 'All Church property is the common wealth of the community of Christ to serve its purpose in proclaiming the gospel. The entire Church is, therefore, responsible for using and managing property. Decisions about property must not be made in isolation, but in relation to one another as the community of Christ.' Any significant property-related decisions must be approved by the Synod Property Board, as all property is legally owned by the Property Trust."*
- Southern Cross Care: *"Aged care and Nursing Homes owned and operated by Southern Cross Care."*

Across all ownership models, approximately 70% of the total funding for RAC is provided by the Australian Government, which pays providers of the service on behalf of care recipients.[14] The Federal Government, through the Aged Care Quality and Safety Commission, also manages the ongoing accreditation of facilities to ensure they are meeting defined quality standards. The Aged Care Quality Standards define a range of criteria by which Aged Care facilities are assessed; of relevance to energy and HVAC is Criteria 5: *The organisation provides a safe and comfortable service environment that promotes the consumer's independence, function and enjoyment.* However, this criterion does not provide detail on what is taken to constitute a comfortable thermal environment.

13. DOH (2020b)
14. Department of Social Services (2014)

iHub identified four main models of RAC facilities in operation in Australia.[15] These are summarised in Table 4.

Table 4. RAC facility accommodation models in use in Australia.

ROLE DESCRIPTION	ORGANISATION
Independent Living Units (ILU)	Apartments or duplexes that are fully self-sufficient. These may be studio units or have 1-3 bedrooms and are typically occupied by a single elderly person or a couple. They can elect the level of care that they require.
Hostels	"Share homes" with independent bedrooms, and shared common spaces. Bathrooms may be ensuite or shared. Small number of residents (e.g. about 10).
Nursing Home	Old style, 'hospital ward' like buildings
Multi-storey 'modern' residential aged care	"Resort style" accommodation where each resident has their own room and en suite. A variety of shared facilities (e.g. dining, lounge, recreation etc) are provided (similar to a holiday resort). Full nursing care provided.

iHub recognised "Aging in Place" as a policy trend that is likely to increase energy intensity of RAC in the future.[16] With the trend towards keeping Australians in their own home as long as possible, it is likely RAC facilities will be places for those requiring more intensive and advanced care—impacting energy consumption.[17]

ENERGY PERFORMANCE POLICY AND PROGRAMS

There is little published data around energy use in RAC facilities in Australia or elsewhere.[18] A NABERS rating for aged care had been planned for release in July 2021.[19] Throughout 2020, NABERS were in the process of collecting the necessary benchmarking data to establish the rating including site details, facility scale, facility features, operational data and energy consumption information.

A RAC facility is essentially a mix of other building types co-located, including residential, healthcare, office and commercial kitchen/laundries, with the relative proportions determined by the accommodation model. Many of these individual spaces have established energy performance benchmarks, however, there is little information available on which to assess the performance of the combined facility.

On the basis of energy audits of 15 RAC facilities, the New South Wales Office of Environment and Heritage estimated heating and cooling accounts for 30% of the total energy consumption and 44% of the electricity use in aged care facilities.[20] The next major end use was energy for hot water heating. The daily profile for aged RAC facilities includes summer morning and afternoon peaks, winter morning peaks, and substantial overnight base load (circa 20% of the overall consumption).[21]

15. Innovation Hub for Affordable Heating and Cooling (iHub) (2020b) http://www.ihub.org.au/wp-content/uploads/2020/06/LLHC1_Healthcare_Sector_Baseline_Energy_Report_V01.pdf Retrieved April 1, 2021.

16. Innovation Hub for Affordable Heating and Cooling (iHub) (2020a) *Living Labs Healthcare Sector Energy Baseline and Key Performance Indicators.* http://www.ihub.org.au/wp-content/uploads/2020/06/LLHC3_Fernhill_Baseline-Energy-Report_V01.pdf Retrieved April 27, 2021.

17. iHub (2020a)

18. iHub 2020b

19. NABERS (2021) Residential Aged Care. https://nabers.govcms.gov.au/file/62944/download?token=HpApplyO Retrieved April 24, 2021.

20. Office of Environment and Heritage (OEH) (2012) *Energy Saver: Aged-Care Toolkit.* http://energycut.com.au/business/wp-content/uploads/2015/02/Aged-Care-Tool-Kit.pdf Retrieved April 1, 2021.

21. OEH (2012)

Air conditioning in aged care facilities is often individually controlled, which increases the risk of excessive operating times, incorrect modes of operation and inefficient temperature set-points.[22] According to a review of government advice provided to RAC operators, there is little guidance for RAC providers on appropriate HVAC operation. The Office of Environment and Heritage recommended setting thermostats at 24°C for cooling in the summer and no less than 20°C for heating in the winter in common areas, as well as increasing the dead-band to 1–1.5°C to save in the energy consumption.[23] Queensland Government recommended maintaining internal temperatures at 24 °C in summer, and 21 °C in winter in their guidance for new facility design.[24]

TYPICAL HVAC CONFIGURATIONS AND MAINTENANCE PRACTICES

Currently, there is a lack of nationwide guidelines on thermal control within aged care facilities as most standards are applied to healthy adults only.[25] While current rules governing the accreditation of aged care facilities in Australia do make reference to the need to provide 'comfortable internal temperatures and ventilation', there is no specific reference to the temperature ranges that are considered comfortable.[26] This at least partially explains reports that many facilities operate without air-conditioning, at least in residents' individual rooms.[27]

The lack of air-conditioning can be problematic, particularly in the hot summer months. Long term monitoring of five RAC facilities in the Illawarra region reported indoor air temperature ranging from 17.2 °C to 31.6 °C. Regression of indoor temperatures against perceived comfort supported the use of the ISO 7720 standard comfort band of 20.0–26 °C.[28] The aged care quality standards have recently been updated. There was draft recommendation regarding ensuring comfortable internal temperatures, however this was not included in the final recommendations.[29]

In aged care facilities that have air-conditioning, the configuration is usually a combination of small individual units in resident rooms and larger packaged direct expansion or variable refrigerant flow units in common areas. These multiple systems are often individually controlled.[30] The study of indoor environmental quality in an aged care facility in Victoria by Noguchi et al.[31] provides more detail:

> *"The heating, ventilation and air-conditioning (HVAC) systems used for climate control are quadrant-based units and they are a combination of ducted air handling units via vertical ducts for the residential zones and fan coil units in communal zones. Heating and cooling are centrally controlled and personalization is only possible in the residential spaces by increasing or decreasing the ventilation by 30% via the panel switch in each residential room."* (p. 288)

22. OEH (2012)
23. OEH (2012)
24. Queensland Government (1999) Design Guidelines for Queensland Residential Aged Care Facilities.
25. NABERS (2021)
26. Tartarini, F., Cooper, P. & Fleming, R. (2018a) Getting the temperature just right helps people with dementia stay cool. The Conversation. https://theconversation.com/getting-the-temperature-just-right-helps-people-with-dementia-stay-cool-97374
27. Sustainable Living Tasmania (2016)
28. Tartarini, F., Cooper, P. & Fleming, R. (2018b) Thermal perceptions, preferences and adaptive behaviours of occupants of nursing homes. *Building and Environment* **132**: 57-69.
29. see for example Connolly, A. (2019) No mandatory air conditioning for aged care residents after pressure from lobby group. ABC news. https://www.abc.net.au/news/2019-02-18/air-conditioning-unlikely-in-final-aged-care-regulations/10820210 Retrieved April 1, 2021.
30. OEH (2012)
31. Noguchi et al. (2019)

This research also found significant temperature variations in communal spaces, while staff rooms were more consistent. Perceptions of temperature and comfort also differed considerably between residents and staff:

> *"During the interview in the summer, some of the inactive senior residents wore scarves and hats while most of the active staff was wearing short sleeved t-shirts."* (p. 299)

OEH reported that heating in RAC facilities is commonly delivered using inefficient portable or fixed electrical heaters.[32] Similarly, energy audits completed in aged care facilities in Tasmania found that in most of the facilities heating was delivered in an *ad hoc* manner.[33] While some facilities had good heating control with wall-mounted thermostats, others relied only on the heater thermostat. Facilities relying on a heater thermostat were considered to be problematic as it led to poor temperature control and was likely to cause overheating.

One key area in which aged care facilities differ from office spaces is the role of residents in controlling the environment. Different facilities provide residents with different adaptive opportunities within their rooms, including openable windows, the ability to turn heating and fans on or off, and adjust HVAC thermostat set points. This means residents can be active in the HVAC system (similar to residential settings), or passive recipients of pre-determined conditions (similar to office settings). Complicating this control picture is the large proportion (50%) of residents in nursing homes living with dementia and other mental or mobility issues that limit their ability to control the environment, and the role of staff in caring for the residents through controlling their internal thermal environment.[34]

KEY QUESTIONS TO EXPLORE:

The review of existing literature highlights that aged care ownership structures differ significantly from that of mid-tier office buildings, and we are expecting that many of the issues identified in mid-tier buildings will not exist in this sector. However, other factors such as the existence of multiple building types and uses with RAC facilities, and the mix of central plant and individual AC units, suggests that there may be some commonality of issues regarding HVAC maintenance. These have been explored further in targeted interviews and focus groups, with a particular focus on:

1. What proportion of RAC is air-conditioned?
2. How is maintenance managed, e.g in house or external, preventative or responsive, etc.?
3. What are the main barriers to improved HVAC performance, and how do these relate to the mid-tier sector findings?

32. OEH (2012)
33. Sustainable Living Tasmania (2016)
34. Tartarini et al. (2018a)

ANALYSIS OF INTERVIEW AND FOCUS GROUP FINDINGS

Based on the finding from interviews with Aged Care facilities managers, HVAC technicians and asset managers, numerous differences between Aged Care facilities and mid-tier commercial office buildings are apparent. The interviews in all cases focussed on Residential Aged Care facilities (RACs); although village type facilities are common, these sites typically use residential air-conditioning systems and are substantively different to the commercial sector.

SPILT INCENTIVES

One of the most important differences between the Aged Care sector and the office sector is the apparent lack of the split incentives issue in the Aged Care sector. Aged Care providers typically own the buildings in which they operate, and in most cases also constructed the facilities. This means that a single entity is responsible for both capital and ongoing operation cost for HVAC equipment. The split between development and operational arms within aged care providers, which was noted as an issue in shopping centres, was also noted in the aged care sector. Those involved in development of new facilities were reported as highly sensitive to upfront cost, and often systems were installed that involve higher ongoing costs as a result.

MAINTAINING COMFORT

A key driver of HVAC system and maintenance decisions in the aged care sector is a legislative requirement to maintain a ‘safe and comfortable service environment’ for the residents. Failure to maintain this standard could theoretically result in loss of accreditation to operate for the aged care provider, According to those interviewed, this means that resident comfort complaints are acted upon, either through temporary fixes (e.g. supplementary heating) or system upgrades if the issue is ongoing.

The main driver for reactive call outs was reported as being comfort complaints from staff members. It was a noted issue that staff and residents often have different thermal preferences due to activity levels, and this can often cause competing operation (e.g. heating vs cooling) between common areas and bedrooms. Whilst the property manager’s primary driver was staying within annual operating budgets, the organisations all reported being very sensitive to an inability to maintain comfort, largely due to the compliance requirements. This was typically reported as a concern about maintaining warmth during winter. The need to maintain comfort and stay within operating budgets anecdotally lead to patching or band-aids to get through to a new budget period, and will likely have negative implications for energy efficiency. In general, the sector was noted as being compliance heavy, with issue that may affect compliance being remedied with as a high priority.

35. There was a boom in RAC construction between 1962 and 1971, following changes to how subsidies were provided under the Aged Persons Homes Act.

HVAC SYSTEMS IN SITU

Amongst those interviewed, the building stock operated was typically mixed, with many older facilities built in the 1960s[35], as well as new and refurbished facilities. Older facilities were typically provided with a centralised heating system (i.e. hydronic with gas boiler). The vast majority of RACs are now air-conditioned, however most facilities did not have complex centralised systems, relying instead on domestic split systems, multi-head split systems, or packaged AC units. Newer systems typically used variable refrigerant flow systems.

MAINTENANCE ARRANGEMENTS

Providers use different organisational structures to manage their facilities. Facilities typically have an onsite general maintenance staff member and a general facility manager, with central asset management support. Some organisations have intermediary management support (i.e. regional managers), particularly if the facilities are spread over large areas. HVAC contractors in the focus group reported that some aged care providers are relying on in-house general maintenance staff to undertake HVAC maintenance for simple systems (i.e. splits). The discretionary budgets for on-site maintenance were typically in the order of $500, with additional budget (of order $5,000) for regional managers. Local maintenance staff would typically make a first basic attempt to fix identified issues with HVAC system, but most issues would require sub-contracting of HVAC technicians.

Aged Care providers had different approaches to engaging HVAC contractors, either engaging a single, large organisation to serve all sites, or engaging different contractors for different sites. The geographically diverse nature of many Aged Care portfolios raised some challenges for HVAC maintenance, as high-quality technicians may not be as readily available in regional areas. Conversely, as a potentially large client for HVAC contractors, some aged care providers were able to access better quality service in regional areas (as perceived by both the provider and the contractors).

CONTRACTS AND EXPENDITURE

HVAC maintenance was predominantly discussed as routine, scheduled or programmed maintenance, and contracting was not complex. In some cases regular maintenance was delivered without a formal ongoing contract. Typically, contractors would be on site in a routine manner to undertake basic maintenance tasks (i.e. filter changes), with additional recommended work being quoted as part of the routine reporting. Despite this, the HVAC contractors played an important role in the ongoing performance of the systems. Recommendations from contractors on whether to patch, repair or upgrade a system, additional preventative maintenance (e.g. chemical cleans), and future capital expenditure were important in setting future budgets and deciding on best options. The maintenance contractors were often also the contractors involved in upgrade works, unless a major system refurbishment was required necessitating a larger capital expenditure, at which point the work would be tendered.

UPGRADE/REPLACE DECISION SUPPORT

There does not appear to be a high level of HVAC knowledge amongst facility management and general maintenance staff, although there was a high level of knowledge regarding the specific systems, and types of issues that occur within the HVAC systems under their operation. In most cases, Aged Care providers will have some level of engineering support in the head office, however the HVAC technicians are clearly an important source of information in this sector. Decisions to upgrade or replace systems were typically made on the basis of increasing maintenance costs for a unit, and energy consumption was not a major consideration. There was not typically a formal system in place for determining appropriate maintenance cost, and decisions were heavily influenced by individual facility or regional manager's expectations of reasonable costs. Aged care organisations typically have an ability to benchmark maintenance costs against the rest of their portfolio. Whilst both benchmarking and lifecycle cost assessments were reported, these were typically informal processes based on an individual's work practices or judgement, rather than an organisational procedure.

The advice of the HVAC contractors was valued in making this decision, and often the starting point for upgrades was a recommendation from the contractor. The HVAC contractor for one interviewed provider, a national HVAC company, did use a sophisticated asset management tracking system in reporting. As noted, many of the systems were relatively simple, low cost residential units. The cost to repair these units was typically not justified, and indeed there was an expressed perception that for the simple split systems, it was not worth having a technician called out in the case of breakdown, and it was better to replace.

ASSET MANAGEMENT PLANNING

In 2017, a new requirement was introduced in NSW for asset management plans to be developed and maintained for retirement villages (these are regulated by the state government). This plan is required to include an asset register, maintenance schedule, and three-year capital maintenance forecasts. For providers in NSW, this new requirement was changing the practices across the organisations. It was perceived that asset management for RACs would change substantially in the coming years, as RACs would eventually be incorporated in the more advanced asset management systems currently being established.

5. HOTELS

HOTELS KEY POINTS

- Hotels appear to be similar to offices in many respects. For example, hotels appear to have similar building stock, HVAC equipment and maintenance practices. Whilst many premium hotels are likely to be undertaking best practice maintenance, it appears that a mid-tier sector with poorer maintenance regimes also exists in the hotels space. Similar to the office sector, this will largely be related to age, location and ownership profile, as well as the star rating of the hotel.
- The issue of split incentives does not appear to be a major issue within hotels, although the organisational split between capital and operating expenditure does appear to exist, and impact on the quality of HVAC systems and maintenance.
- Although guest satisfaction is clearly impacted by HVAC performance, this does not appear to translate into best-practice maintenance for much of the hotels sector. In many cases, HVAC is not given much though or investment, until a major failure or breakdown. Reactive maintenance dominates.
- As for the other sectors, despite the unique features of the hotels sector, HVAC technicians who had experience across sectors reported that the major issues identified through the *Better Ways to Work* survey, such as lowest cost contracting, skill and training shortcoming for technicians and FMs, and lack of clear standards for appropriate maintenance, were also common in this sector.

In Australia the hotels sector is responsible for an estimated 12% of energy use amongst non-residential buildings.[36] Taking data from the ABS reported by CIE, it is estimated that there were a total of:

- 4,445 hotels/motels and serviced apartments in Australia in 2016.

This was comprised of:

- 967 licensed hotels establishments with 15 or more rooms
- 2,404 motels establishments with 15 or more rooms
- 1,074 serviced apartments establishments.[37]

Based on discrepancies between ABS and Australia Hotel Association data, there is potentially more than 2,000 other hotel/motel establishments with less than 15 rooms in Australia.

OWNERSHIP AND MANAGEMENT STRUCTURES

The majority of hotels in Australia are owned privately (64% of total rooms), with publicly-listed companies (30%) and trusts (6%) the other ownership classifications.[38] In their study of Australian hotel ownership, Turner and Guilding have recognised nine main ownership types.[39] These types, and relative frequency in Australia and NZ are shown in Table 5. This study surveyed 200 hotels, so is not necessarily representative of the entire Australian hotel sector.

Table 5. Ownership breakdown of Australian hotels from sample of 200.

	OWNERSHIP CATEGORY	RELATIVE FREQUENCY
1	High net worth private investors	27.0%
2	Specialist hotel management companies (e.g. Accor)	23.5%
3	Listed property trust (various real estate e.g. Mirvac)	13.5%
4	Developer	11.5%
5	Strata-titled ownership	7.5%
6	Unlisted property trust (e.g. Colonial First State)	6.5%
7	Specific listed property trust (only hotel real estate)	3.0%
8	Traditional investment institution (e.g. AMP)	2.5%
9	Opportunity fund (e.g. investment banks)	1.5%
	Other	3.5%

While institutional investors appear to own a large proportion of the Australian hotel market, strata-title is a significant and fast evolving form of Australian hotel ownership.[40] The largest single hotel owner in Australia is Abu Dhabi Investment Authority.[41] Change in leasing and ownership in the hotel sector is generally slow, with sales turnover characterised as very low, and lease turnover low.[42]

Within the hotel sector, it is common to find that major hotel groups (recognisable brands such as AccorHotels, IHG, Marriot, Hilton etc) do not own many of the hotels that they manage. The main hotel ownership and management structures, a description, and relative frequency in Australia/NZ are shown in Table 66.[43]

36. Centre for International Economics (CIE) (2019) *Independent Review of the Commercial Building Disclosure Program*. Report prepared for the Department of Environment and Energy. Canberra: CIE.
37. Energy Action and EnergyConsult (2018)
38. Energy Action and EnergyConsult (2018)
39. Turner, M.J. & Guilding, C. (2014) An investigation of Australian and New Zealand hotel ownership. Journal of Hospitality and Tourism Management **21**: 76-89.
40. Turner & Guilding (2014)
41. Energy Action and EnergyConsult (2018)
42. CIE (2019a)
43. Based on Turner and Guilding (2014)

Table 6. Ownership and management structures common in Australian hotels.

OWNERSHIP/ MANAGEMENT STRUCTURE	DESCRIPTION	RELATIVE FREQUENCY
Hotel Management contract	There is an agreement between a property owner and a hotel operating company. The hotel operating company takes on operational and management responsibilities. The owner owns the property, and bears the risks, and pays the hotel operating company a fee for managing the hotel.	50.5%
Franchise	The hotel owner becomes the franchisee, and for a fee, an independent hotel adopts the franchiser's name and trademarks and receives services in return. Almost all the advantages of the chain are available for the franchisee: mass purchasing, management consultation, wide advertising, central reservations, and systems designs. Adding a further layer, the franchisee may own the franchise rights but then decide to hire a third party operator to run the hotel.	9%
Independently owned and operated	The entity operating the hotel is the same as the entity owning the hotel and no management contract or franchising arrangement has been entered into.	37%
Lease	Involves a landlord and a tenant, with the tenant either operating the hotel directly or subcontracting using franchise or management agreements.	3%

It is difficult to determine prevalence of different ownership/management structures across the whole Australian industry, given the lack of a standard definition of a hotel (e.g. it can be difficult to determine if data includes motels, pub/hotels etc, or often is only referring to major hotel chains), and lack of appropriate publicly available studies. International data regarding prevalence differs substantially from Turner and Guilding's findings,[44] with franchise by far the most common operating model in North America (85%) and Europe (50%).[45]

Another key factor when considering hotel management and the relevance to HVAC systems is the importance to the hotel business of delivering a satisfactory experience to the paying customer. It is likely that hotel guests would be quick to notify management of any issues with HVAC systems in their rooms, and likewise for management to be responsive in rectifying issues. This is reflected in industry analysis of complaint ticket from a single source that found the most common reason for a guest complaint (24% of all complaints) was guests feeling too hot or too cold.[46]

44. Turner and Guilding (2014)
45. Collins, S. & Perret, S. (2015) *Decisions, Decisions... Which hotel operating model is right for you?* https://hvs.com/StaticContent/3672.pdf Retrieved April 2, 2021.
46. https://www.travelpulse.com/news/hotels-and-resorts/hotel-guests-most-common-complaints.html

ENERGY PERFORMANCE POLICY AND PROGRAMS

Hotels are one of the most energy-intensive commercial buildings, primarily due to air-conditioning, space and water heating.[47] An international study by Torres et al.[48] found that HVAC systems take approximately 30 to 50% of hotels' total energy consumption. The *Energy Wise Hotels Toolkit* created by the City of Melbourne suggests that the proportion might be even higher in the Australian context, suggesting as much as 70% of the total energy consumption.[49] The typical end-use breakdown provided shows energy consumption consists of 7% pump, 10% electric heating, 10% AHU, FCU and ventilation fan, 13% space heating, 14% domestic and pool water heating, and 15% chiller.[50] It was noted by the Accommodation Association of Australia (representing accommodation providers including Accor and InterContinental) in their submission to the CBD review that *the biggest requirement for energy is HVAC. Given the 24/7 nature of operations and the high costs associated with capital replacement, energy gains without significant investment in HVAC systems would be difficult to achieve.*[51]

Energy consumption in tourist accommodation and hotels varies widely, with typology, size, age and level of occupancy of each facility. NABERS includes a specific hotel rating tool, however uptake of the tool is low.

At present, only 41 hotels hold NABERS rating. A breakdown of NABERS star ratings for hotels is provided below:

NABERS FOR HOTELS

The NABERS rating for hotels assesses and rates energy and water performance based on the energy and water efficiency of common areas, guest rooms, back of house facilities and on-site amenities. It rates standard, suite, boutique, conference, gaming/casino, ski and spa hotels, and factors in shared space usage in mixed-use buildings into the rating. The rating accounts for all onsite services and amenities unique to the building, including:

- Carparks
- Laundries
- Function and conference rooms
- Spas and saunas
- Indoor/outdoor swimming pools
- Restaurants and cafés
- Gyms

NABERS ratings for hotels adjusts for differences between hotel quality (star rating). Additionally, it adjusts for fluctuating occupancy rates over the year.

47. Dhirasasna, N., Becken, S. & Sahin, O. (2020) A systems approach to examining the drivers and barriers of renewable energy technology adoption in the hotel sector in Queensland, Australia. *Journal of Hospitality and Tourism Management* **42**: 153-172.

48. Torres, Y.D., Herrera, H.H., Plasencia, M.A.A.G., Novo, E.P., Cabrera, L.P., Haeseldonckx, D. & Silva-Ortega, J.I. (2020) Heating ventilation and air-conditioned configurations for hotels: an approach review for the design and exploitation. Energy Reports **6**: 487-497.

49. City of Melbourne (2007) *Energy Wise Hotels – TOOLKIT*. https://nsfsakai.nthsydney.tafensw.edu.au/access/content/group/179a89f1-0f5a-4f18-90a1-ecbe32dd40d4/Floristry/11_S2_RY_Participate%20in%20Environmentally%20sustainable%20Work%20Practices%20-%20Floristry/Student%20resources/Energy%20Wise%20Hotels.pdf Retrieved April 2, 2021: p. 6.

50. City of Melbourne (2007): p. 9

51. CIE (2019)

Figure 1. Hotels' NABERS star ratings (Source: NABERS)

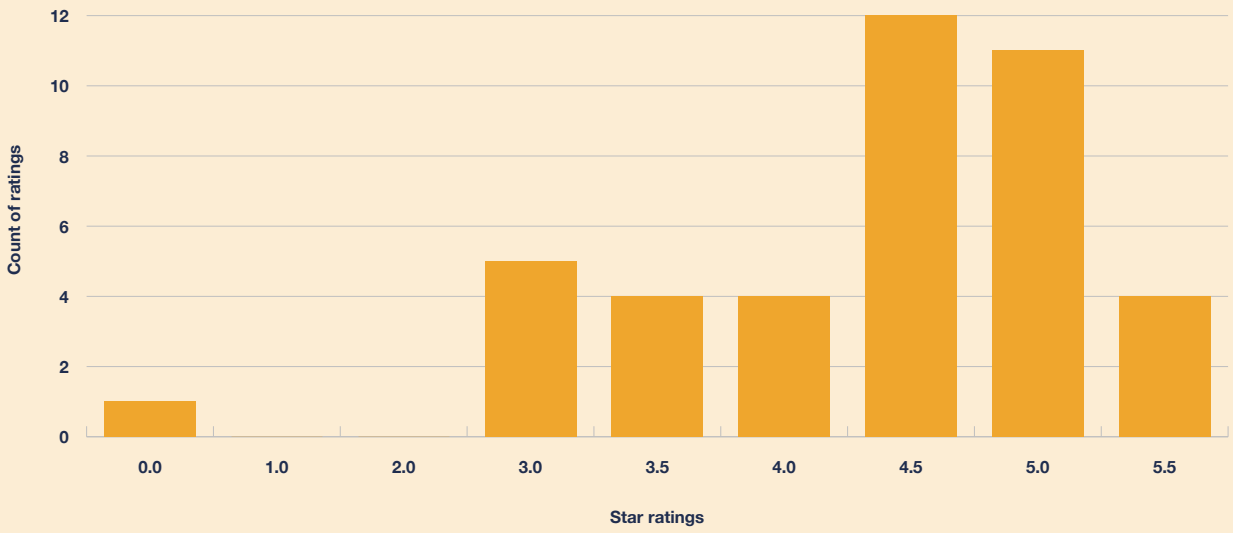
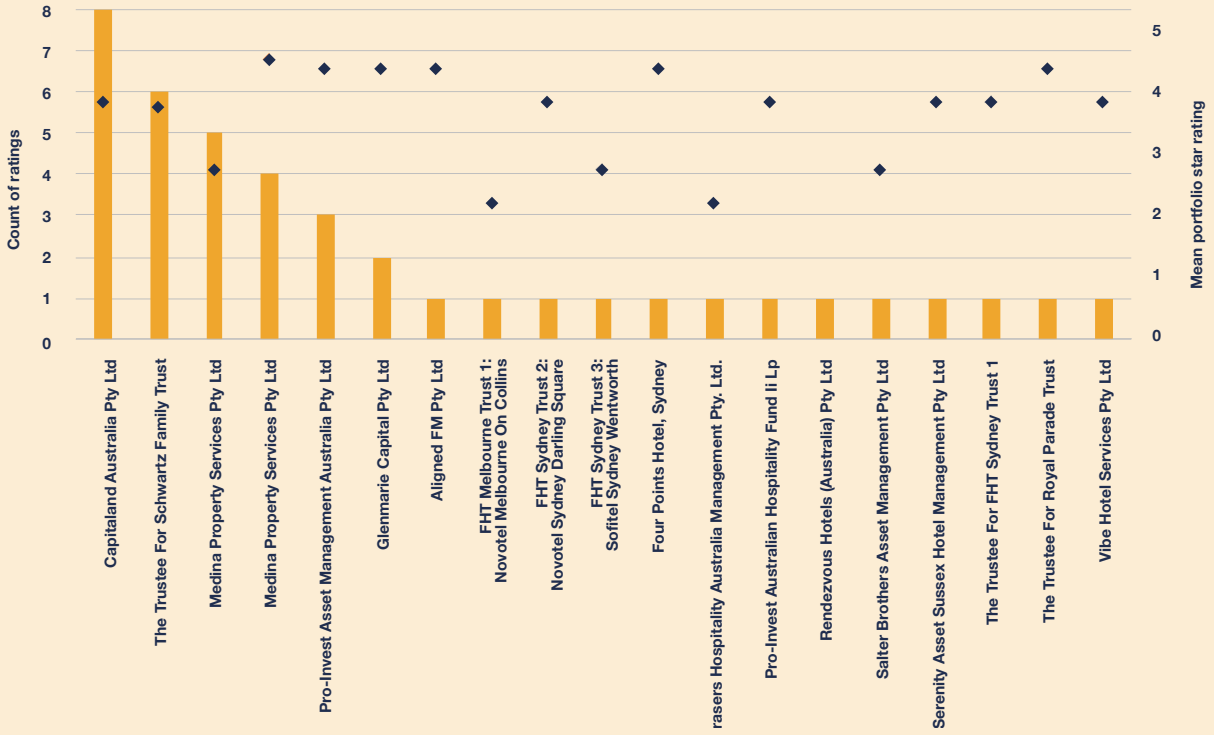


Figure 2. Average NABERS Star rating per owner for hotels (Source: NABERS)



Whilst other sustainability rating tools exist for hotels, e.g. Green Globe and Global Sustainable Tourism Council, there does not appear to be rating tool with a similar focus on energy consumption of operations.[52] A review of hotel sustainability policies found that few hotels (26%) included any environmental related information on their websites, and that independent non-chain affiliated hotels appeared not to have adopted environmentally sustainable policies and practices in any visible way.[53]

52. CIE (2019)

53. Khatter, A., McGrath, M., Pyke, J., White, L. & Lockstone-Binney, L. (2019) Analysis of hotels' environmentally sustainable policies and practices. *International Journal of Contemporary Hospitality Management* **31**(6): 2394–2410.

According to the City of Melbourne, depending on the HVAC configuration, control and operation, up to 50% improvement in energy efficiency is achievable by: retrofitting an economy cycle, installing a heat recovery system (economiser), installing variable speed drives, reducing the infiltration of ambient air, setting room temperature appropriately, and using energy efficient chillers.[54] Many hotels are already investing in electricity saving practices, including controls and BMS upgrades.[55]

TYPICAL HVAC CONFIGURATIONS AND MAINTENANCE PRACTICES

As for other sectors, it is difficult to find generic or typical configurations for hotel HVAC. It is likely that there will be diversity according to both property type and quality. For low–rise hotels, motels, and lower quality hotels, individual room split systems will be more common. Higher density and better quality hotels will be expected to have centralised equipment.[56] A study of 16 hotels in Hong Kong (ranging from 3-5 star) found that all were centrally air-conditioned, with 14 having their own central chiller plants. The other two were part of a larger building complex.[57] It is common that the HVAC systems operate on partial load conditions and requirements vary from room-specific fan heating and cooling to central air-conditioning of the whole premises, depending on the hotel rating.[58] According to Torres et al.[59] hotels with three or more stars typically require individual heat control in each bedroom.

Recent concerns regarding COVID-19, particularly in quarantine hotels, has placed a focus on hotel air distribution and HVAC, both in terms of operational design and maintenance. In a HVAC&R news article on this issue, high-rise hotel rooms were characterised as commonly having a fan coil unit over the room entrance area or bathroom which uses outdoor air either ducted down the corridor or supplied via openable windows, and exhausted from the bathroom (although noting that each hotel will be different). Basic requirements for “air changes” in functional rooms and areas have been legislated in Australian Standards (e.g. AS/NZS 1668.23). However, recent COVID-19 outbreaks have highlighted the lack of national standards on hotels and the need to assess and improve poor ventilation.[60] Adjusting the HVAC systems can minimise the risk of spreading COVID-19 by allowing more air circulation in common areas, limiting the use of recirculated air, and increasing the outside air intake.[61] The current trend in hotels has been to cut down maintenance costs to the minimum. Poorly maintained HVAC systems in hotels have raised major concerns, particularly during the COVID-19 pandemic.

The City of Melbourne’s *Energy Wise Hotels Toolkit*, the recommends that hotels move from preventative and breakdown maintenance to ‘energy efficient maintenance’ as a way to reduce energy costs and extend the lifecycle of equipment.[62] This energy efficient maintenance includes replacing filters in air handling units and fan coil units, calibrating the thermostat control, cleaning the motor casings, adjusting the V-belt tension, and checking the damper control.[63] Also regular checking of cooling tower performance, rewinding and voltage supplied to the motors is considered to increase energy efficiency.[64] This is relatively generic advice that would apply across many building sectors.

54. City of Melbourne (2007): pp. 21-22

55. Dhirasasna et al. (2020)

56. Torres et al. (2020). See also Deng, S. M. & Burnett, J. (2000) Study of energy performance of hotel buildings in Hong Kong. *Energy and Buildings,* **31**(1): 7–12 and Mechri, H. eddine & Amara, S. (2021) Investigation and analysis of energy and water use of hotel buildings in Tunisia. *Energy and Buildings* **241**: 110930.

57. Deng & Burnett (2000)

58. Torres et al. (2020)

59. Torres et al. (2020)

60. Dow, A. (2020) Ventilation blamed for COVID spread, as design problems are detected. The Age. https://www.theage.com.au/national/victoria/ventilation-blamed-for-covid-spread-as-design-problems-are-detected-20201219-p56ox4.html Retrieved April 2, 2021. Dow, A. (2021) Ventilation assessments overlooked in hotel quarantine relaunch. The Age. https://www.theage.com.au/national/victoria/ventilation-assessments-overlooked-in-hotel-quarantine-relaunch-20210212-p5721m.html Retrieved April 2, 2021.

61. Safe Work Australia (2020) Heating, Ventilation and Air Conditioning (HVAC) Systems. https://www.safeworkaustralia.gov.au/covid-19-information-workplaces/other-resources/heating-ventilation-and-air-conditioning-hvac Retrieved April 13, 2021

62. City of Melbourne (2007)

63. City of Melbourne (2007): pp. 19-20

64. City of Melbourne (2007): p. 20

KEY QUESTIONS TO EXPLORE:

Based on this review of existing literature, there are a number of different ownership structures operating within the hotel sector. It is likely that, similar to the commercial office sector, there will be a 'mid-tier' within the hotel sector, likely within the lower quality (lower star rating), and franchise (diverse ownership) hotels. The strength of the driver to be highly responsive to guests' comfort needs and complaints are a significant point of difference. These factors, along with aspects of HVAC system configurations, was explored further in targeted interviews, with a particular focus on:

1. Who has responsibility and agency for which aspects of the management of HVAC? Who employs the FMs?
2. Where does HVAC maintenance sit with respect to guest satisfaction? What are the incentives and motivations for good maintenance (e.g. cost, complaints, etc…), to what degree is HVAC a conscious consideration of Hotel management?
3. Is there a mid-tier in hotels sector?
4. What are the main barriers to improved HVAC performance, and how does these relate to the mid-tier sector findings.

ANALYSIS OF INTERVIEW AND FOCUS GROUP FINDINGS

As noted above, the hotels sector is diverse in terms of size, building type and ownership profile. In order to provide focus for the interviews and focus groups, discussion was directed towards larger hotels, as motel and small hotels typically use domestic air-conditioning systems. Within this sector, hotels appear to operate in a relatively similar manner to the office sector. The HVAC equipment and building stock is relatively similar. Typical HVAC configurations include a central chilled water plant with fan coil units serving individual rooms, although there were many examples of the use of packaged units or split systems, even in large hotels.

MAINTENANCE STANDARDS

There also appears to be similar differences in performance and maintenance practices between 'premium' and lower quality hotels. The source of these differences was not clear cut. Although higher star ratings were generally perceived as having better maintenance practices and performance, many examples were given of prestige hotels with poor maintenance practices. Similarly, some multinational hotel groups were held up as examples of best practice due to the in-house experience, maintenance policies, and sustainability goals. However, this was not uniform amongst multinationals and others were identified as poor performers; regulation and expectations of maintenance within the home nation of multinationals was identified as a possible explanation for these differences. There were examples amongst prestige hotels of best practice predictive maintenance and energy efficiency works.

SPLIT INCENTIVE

In terms of ownership and tenancy, the findings from the literature were confirmed by the participants. Most hotels are either owner-operated, or operated under a hotel management agreement. In both cases, the hotel operating company is responsible for all HVAC maintenance, replacement and upgrade works. Similarly, facilities mangers (known as chief engineers) are employed by the hotel management company. This suggests that, similar to aged care, the issue of split incentive should not be significant in the hotels sector, and the difficulty in communicating with the owner should not be a significant barrier to effective HVAC management.

MAINTENANCE ARRANGEMENTS

Similar to office buildings, the career path to becoming a hotel chief engineer appears to be diverse, and often related to time within an organisation, rather than specific training and qualifications. Typically, hotel facilities managers would not be trade qualified, and it is rare for hotels to employ trades in-house. As such, the level of knowledge regarding HVAC and the benefits of appropriate maintenance was diverse, ranging from high-level engineering knowledge, to essentially nil. Respondents reported a lack of training available for FMs in hotels, and no clear pathway into the profession. One major hotel chain was reported to have recently outsourced facilities management, however in general outsourcing is rare in this sector.

Similar to the aged care sector, hotels are very sensitive to equipment breakdown due to loss of income potential whilst rooms are unavailable during repairs and upgrades. A major driver in all decision making is to avoid closing all or part of the hotel for maintenance or refurbishment. One respondent with experience in the sector suggested that some hotels will avoid major refurbishment tasks through patching for as long as possible, then sell on assets rather than close and upgrade the system. Typically, refurbishments that are undertaken are works that can be completed on a room by room basis, rather than requiring floor or whole of site closures. This impacts on maintenance practices, as best practice solutions that would require major replacements are typically avoided if possible, in favour of patch repairs.

MAINTAINING COMFORT

Guest comfort rates extremely highly as a KPI for facility managers, and issues with air-conditioning were regularly reported as a main source of guest complaints. As such, HVAC was a central part of the role of an FM. However, amongst a large section of the hotels sector (i.e. non-premium hotels), this does not appear to translate into best practice maintenance practices. Rather, for many of these sites maintenance is managed to minimise costs, and urgent repairs are undertaken if there is a breakdown or failure. It was clear from the focus groups that inspecting in-room AC filters when visiting as a paying guest is a common practice amongst HVAC contractors, and almost all participants reported they typically found filters were poorly-maintained.

COMPLIANCE

As public spaces, hotels were seen to have a relative high concern for maintaining compliance with relevant Australian Standards, namely fire safety and legionnaires. To this end there does appear to be a minimum level of routine maintenance, and documentation of this maintenance, that would be expected to be undertaken in the vast majority of hotels. This was clearly seen as being essentially to ensure insurance coverage in the event of a fire or other emergency, however there was a clearly expressed concern about the quality of this compliance maintenance; i.e. although routine maintenance would be documented there was not necessarily confidence that the checks would have been undertaken to an appropriate standards. There did not appear to be any form of compliance checking or oversight, rather each hotels would manage their risk as they saw appropriate.

6. SHOPPING CENTRES

SHOPPING CENTRE KEY POINTS

- Shopping centres appear to be similar to offices in some respects, with important differences. Many of the portfolio owners in the premium office space are also owners of shopping centres, and therefore maintenance practices and energy performance is expected to be relatively similar. It is likely that there is a mid-tier in shopping centres, largely related to ownership profile, although this is likely to be much smaller proportion than in the office space due to the relatively centralised ownership.
- There is an interesting relationship between anchor tenants and centre owners, as there is a clear split incentive at work. Anchor tenants are typically responsible for their own maintenance, with owners responsible for any replacement or upgrade works, meaning that reducing ongoing operational costs is not likely to be a strong motivation for upgrades. There is also an additional incentive for tenants to undertake appropriate maintenance (to ensure that any breakdowns are not caused by inappropriate maintenance), however this does not necessarily translate into best-practice maintenance.
- There was evidence of best practice amongst supermarkets. The major chains were highlighted as being concerned with management and maintenance of HVAC, largely due to the substantial refrigeration in their stores, and the energy use and cost implications of this.
- Shopping centres were identified as 'compliance heavy', and very concerned with ensuring all obligations were met and documented, to maintain insurance coverage in public spaces.
- Despite these differences, HVAC technicians who had experience across sectors reported that the major issues identified through the *Better Ways to Work* survey, such as lowest cost contracting, skill and training shortcoming for HVAC contractors and FMs, and lack of clear standards for appropriate maintenance, were also common in this sector.

OWNERSHIP AND MANAGEMENT STRUCTURES

In Australia the retail sector is responsible for an estimated 36% of energy use amongst non-residential buildings, and accounts for the largest proportion of energy use in a single non-residential building sector.[65] Taking data from IBISWorld reported by CIE, it is estimated that there are:

- 1800 shopping centres in Australia in 2016/17
- 588 shopping centres with more than 10 000 m2 of Gross Lettable Area Retail (GLAR)
- 427 with more than 15 000 m2 of GLAR.

The Shopping Centre Council of Australia (SCCA) estimated that in 2018 there were 1,630 shopping centres in Australia with a floor area greater than 1,000 m2 (GLA), and broke these down into:

- 78 regional shopping centres (i.e. those that include at least one department store)
- 291 sub-regional centres (i.e. those that include at least one discount department store as the major anchor tenant)
- 1,120 neighbourhood or supermarket-based shopping centres (i.e. those that include at least one supermarket as the major anchor tenant)
- 96 CBD centres.[66]

Many shopping centres are managed, and often owned and managed, by large and diversified property groups. According to the SCCA, the five largest shopping centre owners, by GLA, are:

- Scentre Group (Westfield, own and manage 42 centres)
- Vicinity Centres (Own and manage 63 centres)
- Stockland (Own and manage 30 shopping centres)
- QIC Global Real Estate (24 shopping centres)
- GPT Group (Own and manage 12 shopping centres).

Other large ownership groups include Dexus (13 centres), Charter Hall (64 centres, in multiple funds), and AMP capital (28 retail centres). CIE reports that the 7 largest ownership groups account for more than 50% of the shopping centre floor area.[67]

Similar to the premium and A-grade office sector, shopping centres can be separated in base buildings and tenancy. The large portfolio owners, who own many of the base buildings typically have corporate social responsibility (CSR) policies governing energy use and environmental impact, for example:

- Scentre: *Our primary environmental target is net zero emissions by 2030 across our wholly owned portfolio.*
- Centres: *Vicinity has set a public target to achieve Net Zero carbon emissions by 2030 for our wholly owned retail assets.*

65. CIE (2019)
66. Shopping Centre Council of Australia (2018) *Key Facts.* https://www.scca.org.au/industry-information/key-facts/ Retrieved April 2, 2021
67. CIE (2019)

Shopping centres are also characterised by anchor tenants, i.e. large supermarket or department stores renting substantial portion of the centre floor space. These anchor tenants are also typically large national or multinational organisations, who will also have CSR policies regarding energy use, for example:

- Woolworths: Our validated science base target is to reduce absolute scope 1 and 2 GHG emissions 63 per cent by 2030 from a 2015 base year.
- Coles: To deliver net-zero greenhouse gas emissions by 2050; For the entire Coles Group to be powered by 100% renewable electricity by the end of FY25…. And; to reduce combined Scope 1 and 2 greenhouse gas emissions by more than 75% by the end of FY30 (from a FY20 baseline).

Further, these anchor tenants have the ability, and in most cases the requirement under the Australian National Greenhouse and Energy Reporting Scheme, to track and report on the energy performance of their stores and portfolio. This provides an important toolkit to allow these groups to identify poorly performing locations, and either upgrade the tenant fit-out, or strongly advocate for base building upgrades. As an example, all Woolworth's stores are connected to an energy management centre, allowing for effective benchmarking and opportunity identification.

According to CIE, the lease arrangements for shopping centres are similar to offices, and therefore can be gross lease (i.e. energy costs are owners' responsibility) or net lease (i.e. energy costs are tenants' responsibility).[68] It is reported as more common for large tenants to negotiate gross rent, and smaller tenants typically net rent, with energy costs additional. In either case, utility costs will be a small portion of the total cost of ownership of a shopping centre (estimated by IBIS world at 2.5%).[69]

ENERGY PERFORMANCE POLICY AND PROGRAMS

Compared to residential buildings, there is limited research to understand the energy and water use of Australian retail sector.[70] The complex boundaries between tenant and landlord responsibilities have made the implementation of energy efficiency policies hard within the retail sector.[71]

NABERS has included a specific shopping centres rating tool for more than 10 years and usage of the tool in the sector is moderate. At present, 168 shopping centres hold NABERS ratings, approximately 10% of all centres over 1000 m2 GLA.

NABERS FOR SHOPPING CENTRES

The NABERS rating for shopping centres assesses and rates all services provided by a shopping centre owner to its retail tenants, and the centre's associated back of-house requirements. This includes:

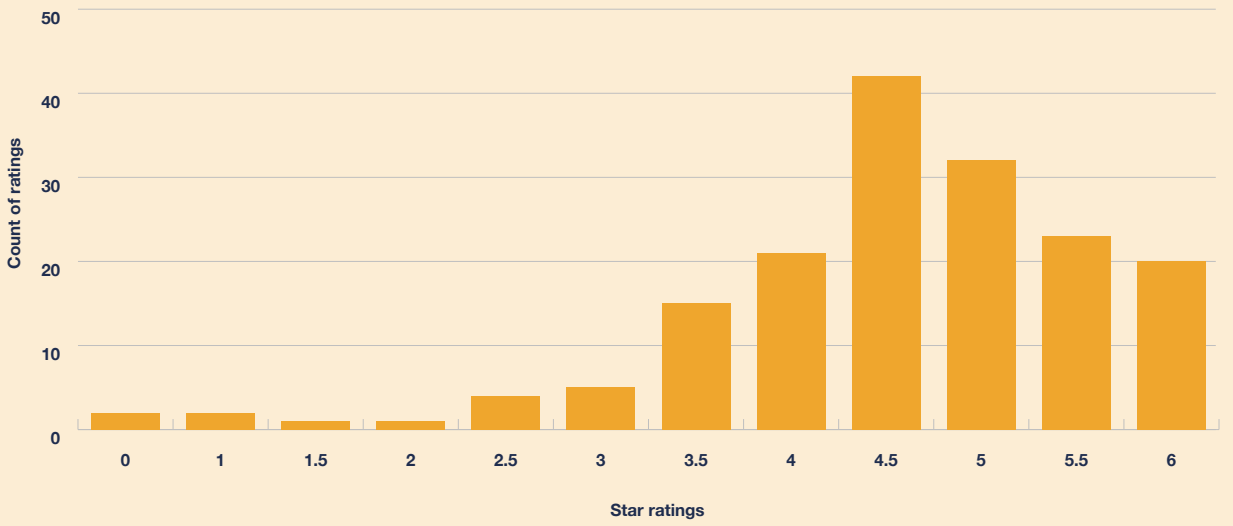
- All services provided to common areas
- Air-conditioning provided to tenants
- Water consumption across retail applications
- Car parks
- Vertical transportation in common areas
- Exterior lighting and signs

NABERS ratings for shopping centres are based on actual operational data related to the central services or common areas controlled by the shopping centre owner, over a 12-month period. A shopping centre can be rated based on its energy use or its water use or both.

68. CIE (2019)
69. CIE (2019)
70. Iyer-Raniga, U. & Moore, T. (2013) A whole of life approach to improve the energy efficiency of the retail sector: An Australian case study. *Proceedings of the SB 13 Singapore – Realising Sustainability in the Tropics*. https://www.researchgate.net/publication/259334470_A_whole_of_life_approach_to_improve_the_energy_efficiency_of_the_retail_sector_An_Australian_case_study Retrieved April 2, 2021.
71. CIE (2019)

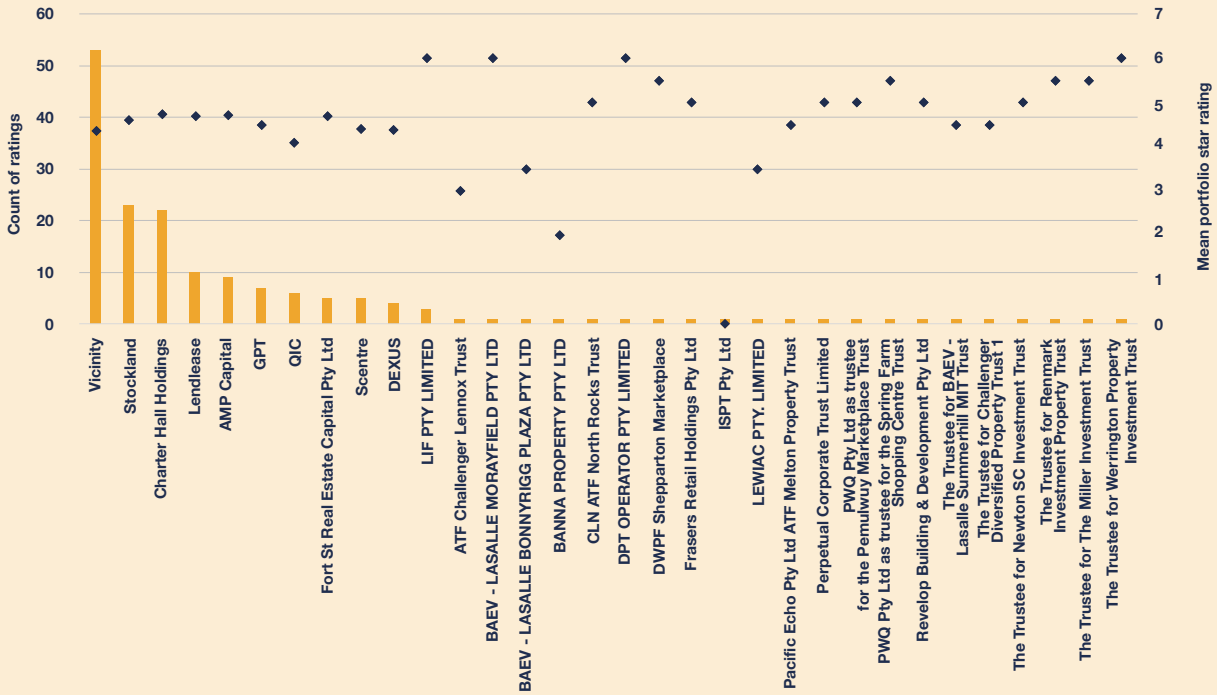
A breakdown of NABERS star ratings for shopping centres is provided in Figure 3, showing that shopping centres that have chosen to complete a NABERS rating tend to be at the higher end of the rating scale.

Figure 3. NABERS star ratings for shopping centres (Source: NABERS)



The NABERS shopping centre is dominated by a small number of portfolio owners, as shown in Figure 4

Figure 4. Average NABERS Star rating per owner for shopping centres (Source: NABERS)



However, shopping centres are not currently included in the Commercial Building Disclosure Scheme. A recent review did not recommend shopping centres be included in an expanded scheme, and stated as justification:

- *A large share of shopping centres (almost half of the centres above 15,000 m2) use NABERS energy ratings voluntarily*
- *Mandatory disclosure could be beneficial if shopping centre owners or operators were unaware of their comparative energy performance. The evidence does not support this for the majority of shopping centres. Whether or not they are using and disclosing NABERS energy ratings, shopping centres are monitoring their performance, and based on the information available those not rated with NABERS have achieved similar improvements in their energy efficiency.*
- *Mandatory disclosure could be beneficial if there was demand from tenants in shopping centres. Tenant groups have indicated that they receive information on costs, including energy costs. Energy efficiency disclosure of the shopping centre is not information that they would use.*[72]

In line with advice in the draft report, DISER is currently offering free NABERS assessments for shopping centres with a GLA between 5,000 and 15,000 m2.

Within shopping centres, supermarkets are a particularly energy intensive sector. The commercial buildings baseline study estimated that supermarkets use more than twice the energy on a per square metre basis than other commercial building types.[73] Cold Hard Facts attributes this to i) longer running hours 96 hours/week compared to just over 59 hours/week for other retail tenancies, and ii) a high penetration of refrigeration systems in supermarkets (normalised for running hours supermarkets still use more than 30% more than other building types).[74]

72. CIE (2019): p8

73. Department of Climate Change and Energy Efficiency (DCCEE) (2012*) Baseline Energy Consumption and Greenhouse Gas Emissions - In Commercial Buildings in Australia*. Canberra: Department of Climate Change and Energy Efficiency, November 2012.

74. Department of Sustainability, Environment, Water, Population and Communities, (SEWPaC) (2013) *Cold Hard Facts 2: A study of the refrigeration and air conditioning industry in Australia.* https://www.environment.gov.au/system/files/resources/fa48d00d-1fb9-4797-90f4-47a6eed2c9c7/files/cold-hard-facts2.docx Retrieved April 1, 2021: p. 96

74. Department of Sustainability, Environment, Water, Population and Communities, (SEWPaC) (2013) *Cold Hard Facts 2: A study of the refrigeration and air conditioning industry in Australia.* https://www.environment.gov.au/system/files/resources/fa48d00d-1fb9-4797-90f4-47a6eed2c9c7/files/cold-hard-facts2.docx Retrieved April 1, 2021: p. 96

TYPICAL HVAC CONFIGURATIONS AND MAINTENANCE PRACTICES

There is little in the way of published literature regarding typical HVAC configuration for large shopping centre buildings in Australia, beyond case studies reports of system upgrades, or similar. In a doctoral thesis, Bridge outlined the major components of a retail HVAC system requiring maintenance as: chillers, air handler units, water pumps, compressors, plant room switchboards, package units, smoke and exhaust fans, cooling towers, boilers, and building management systems.[75] Essentially, the base building systems are expected to be similar to a large office; that is a central plant and distribution system. On top of this, centres which include supermarkets will have large refrigeration plants. Cold Hard Facts estimate refrigeration makes up 50% of a supermarket's energy demand.[76]

It is therefore anticipated that maintenance requirements and practices would be similar to those in the office sector, though likely that of the premium grade office buildings; as reported by CIE (2019 p98):

- *Shopping centres tend to be larger professionally managed buildings that understand the cost trade-offs for different decisions impacting on energy use.*
- *Consultations with shopping centre owners that do not use NABERS indicated that they understood their energy use relative to others and they measured their energy performance.*

KEY QUESTIONS TO EXPLORE

As stated above, this review of existing literature indicates that there are likely to be similarities between maintenance requirements and practices of the office building and shopping centre sectors. The extent to which this mirrors the premium end of the office market, and the existence of a comparable 'mid-tier' within shopping centres was explored further in targeted interviews, with a particular focus on:

1. Typically, who has responsibility and agency for what in the management of HVAC between portfolio owners and anchor tenants? Who employs the FMs?
2. Is there a mid-tier in shopping centres; that is, shopping centres that are not owned by portfolio owners, and who do not have national or multinational anchor tenants?
3. What are the main barriers to improved HVAC performance, and how do these relate to the mid-tier sector findings.

ANALYSIS OF INTERVIEW AND FOCUS GROUP FINDINGS.

At a high level, results from our interviews with sector stakeholders suggest that it is likely that many of the issues identified in the mid-tier office sector will likely also exist in the shopping centres space, albeit only amongst certain shopping centres. The sector appears similar to the office sector, in that there is a large diversity amongst the building stock, system quality, and ownership types. Many of the issues identified from the survey were reported as likely to exist, but predominantly in shopping centres owned by 'high net worth' individuals and international investors. As noted above, the vast bulk of shopping centre floor space is owned by institutional investors (i.e. Real Estate Investment Trusts). These properties appear similar in management to the premium office space; they are managed by organisations with a corporate social responsibility policy, asset management professionals, and environment and energy monitoring and performance targets. Whilst this suggests the mid-tier will be smaller in this sector than the office sector, relative to its size, many of the same issues will likely be present. There are also several structural differences that will influence HVAC maintenance and management practices.

75. Bridge, A.J. (2008) *The determinants of the governance of air conditioning maintenance in Australian retail centres.* Doctoral thesis: Queensland University of Technology.
76. SEWPaC (2013): p. 96

SPLIT INCENTIVES

In the shopping centres space, there is an interesting division in responsibility for HVAC equipment between owners and tenants. Typically, the anchor tenant will be involved in the mechanical design of a new facility, and while the owner will own the plant, the maintenance responsibilities will fall to the anchor tenant for the life of the system or lease. The owner is responsible for the maintenance of HVAC to the common areas and speciality shops (e.g. all non-anchor tenants). This means there will often be two contractors conducting maintenance in the centre, one engaged by the facility owner, and one by the anchor tenant. For the anchor tenants, in the case of equipment failure or poor performance necessitating a capital upgrade, this will fall to the owner so long as the equipment has been appropriately maintained over its lifetime. In the cases where supermarkets are the anchor tenant, they will typically own and maintain all refrigeration equipment, and employ or engage a dedicate contractor across several stores.

Similar to ownership, there was diversity regarding engagement within the anchor tenants groups. Supermarkets were noted as having a good understanding of their energy use and energy savings opportunities, while other department stores were regarded as less developed in their understanding. Likewise, anchor tenants had differing ability to influence owner decision regarding HVAC upgrade options for their sites, and were typically not closely involved in the process.

MAINTENANCE ARRANGEMENTS

Appropriate maintenance is typically defined as maintenance to manufacturer recommendations, and relevant Australian standards (i.e. AS3666.1 and AS1851). DA19 was reported as referenced regularly, but not implemented in the shopping centre space due to the additional cost of implementation. There is an option for 'performance-based' maintenance in AS3666.1, which allows for reduced maintenance visits based on a risk management plan, which would typically be prepared by a third party contractor. Documentation of maintenance is therefore of particular importance in this relationship, as documentation, as well as plant inspections, are relied upon to demonstrate appropriate maintenance. Third parties will often get involved to determine whether maintenance has been enacted to an appropriate standard. For REITs, there is an additional incentive to do maintenance 'to standard', being the requirements of their insurance. This ensures, at a minimum, that all components are serviced according to the minimum requirements defined, and in many cases the REITs will engage a third party to undertake compliance audits to ensure this is being completed. This is not common for smaller owners.

There does appear to be a mid-tier in the shopping centre space. The larger portfolio owners were reportedly typically willing to invest up-front capital if the lifecycle benefits exists for upgrades. This was also reported for supermarket tenants, but less so for other anchor tenants. On the other hand, HVAC contractors with experience in the smaller centres, and centres not owned by portfolio owners reported that these centres were highly sensitive to upfront cost, and were primarily willing to spend money on front-of-house upgrades, rather than upgrades to HVAC services that are not highly visible to the public.

LIFECYCLE ASSET MANAGEMENT

In terms of barriers, several of the key barriers identified in the mid-tier work were repeated as prevalent in the shopping centre sector. The issue of poor initial system design, as well as poor design of replacement and upgraded systems was repeated. A structural split-incentive within REIT ownership groups was identified, where the development group have a strong incentive to maximise development returns, and thereby minimise capital expenditure during construction. Once operational, the operation group (a different department within the REIT) will take over, and they will typically look at improving performance and lifecycle cost assessments. It was reportedly not uncommon for major system overhauls to be undertaken shortly after construction to rectify system design shortcomings. An issue was also identified regarding system upgrades, where some engineering and design consultants are incentivised to present either like-for-like replacements or commonly implemented systems rather than undertake a full system redesign based on site-specific needs. In some cases, the HVAC contractors have a role in the system redesign, but this will vary according to the relationship with the owner.

FACILITIES MANAGEMENT PRACTICES

Similar to the mid-tier finding, there is a wide diversity of backgrounds amongst FMs in this space, resulting in different levels of knowledge and engagement with the operation and maintenance of HVAC equipment. In the premium segment of this sector, FMs typically have an energy saving performance target, and therefore tend to be engaged in the ongoing management of HVAC, as the largest energy end-use under their control. However, they also tend to have access to high quality data and analytics regarding their energy performance. This is not common amongst centres own by individuals. In all cases, tenant comfort and complaints is a key driver.

COMMUNICATION WITH OWNERS

The issue of owner relations was also recurring. It was identified that the ability to have direct contact with the owner was essential to communicating the benefits of more expensive upgrades, and that once a relationship was established with the owner, they are typically responsive to suggestions regarding additional maintenance and/or upgrade options. Understanding the specific drivers and financial hurdles for each owners was important for communicating value. Government incentives scheme were specifically mentioned as valuable in convincing owners to go beyond the lowest cost option when upgrading.

SKILLS AND TRAINING

It was noted that there was a noted trend towards supermarkets employing their own HVAC contracting teams. This was discussed in the context of supermarkets being very cost focussed with contractors and requiring 24/7 responsiveness to issues. It was suggested that supermarket HVAC workers had a high burn-out rate.

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