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Mapping decision-making and opportunities for improving energy efficiency across the mid-tier HVAC maintenance lifecycle

Matthew Daly

Chantel A. Carr

Inka Santala

Daniel Daly

Elyse Stanes

See next page for additional authors

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Abstract

This report looks at the HVAC maintenance lifecycle to outline the decision-making processes that characterise the procurement of HVAC management and maintenance services in mid-tier commercial buildings. It maps a range of policy options against key issues identified across the HVAC maintenance lifecycle.

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Authors

Matthew Daly, Chantel A. Carr, Inka Santala, Daniel Daly, Elyse Stanes, and Pauline M. McGuirk

BETTER WAYS TO WORK

MAPPING DECISION-MAKING AND OPPORTUNITIES FOR IMPROVING ENERGY EFFICIENCY ACROSS THE MID-TIER HVAC MAINTENANCE LIFECYCLE

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ABOUT THIS REPORT

Title: Mapping decision-making and opportunities for improving energy efficiency across the mid-tier HVAC maintenance lifecycle.

Project Team:
Australian Centre for Culture, Environment, Society and Space (ACCESS)
Dr. Chantel Carr, Dr. Elyse Stanes, Prof Pauline McGuirk, Inka Santala

Sustainable Buildings Research Centre (SBRC)
Dr. Matthew Daly, Dr. Daniel Daly

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EXECUTIVE SUMMARY

Through 2020/21, the University of Wollongong in collaboration with the Australian Department of Industry, Science, Energy and Resources (DISER) and several industry organisations, delivered the largest national survey of facilities managers, HVAC contractors and associated design and systems specialists undertaken to date. The *Better Ways to Work* survey provided a substantial new empirical data source for understanding how the HVAC repair and maintenance workforce engages with buildings and technologies, building owners and tenants, governance authorities and regulators, and with each other through formal institutions, and through informal, everyday working relationships.

This report presents findings from a subsequent study that has built on the *Better Ways to Work* survey. This study has produced a more detailed empirical understanding of the decision-making processes that characterise the procurement of HVAC management and maintenance services in mid-tier commercial buildings. It maps a range of policy options against key issues identified across the HVAC maintenance lifecycle.

A cohort of participants were recruited from the *Better Ways to Work* study with the aim of better understanding the complex issues that inhibit energy performance in mid-tier buildings. Three major activities were undertaken:

1. Cluster analysis of the original survey results to determine specific areas of interest for further investigation in qualitative interviews;
2. Qualitative interviews with HVAC and facilities management professionals in the mid-tier building sector, incorporating in-depth discussion of HVAC maintenance workflow; and
3. Modified Policy Delphi survey process with HVAC and facilities management professionals.

The in-depth interviews helped to develop a series of HVAC maintenance workflow diagrams, illustrating the stakeholders and steps involved in undertaking different types of maintenance activities. Common issues or sticking points in this process were then identified by the interview participants.

Following the in-depth interviews, an iterative Policy Delphi survey was undertaken with a panel of respondents, to validate and provide greater insights regarding the key issues identified in mid-tier HVAC maintenance. Issues were ranked by participants in terms of the impact they have on maintenance quality, and the frequency with which they are encountered. While the rankings are useful for prioritisation, one of the key takeaways from this work was that practically all the key issues that were identified were seen as common and impactful by frontline HVAC maintenance professionals. The key issues are discussed in Section 4. The HVAC maintenance lifecycle is also summarised here in a single diagram (Figure 2). In the last round of the Policy Delphi, a variety of policy options to respond to these issues were prioritised by the participants. The results of this are presented in Section 5.

The four issues that were ranked as the most impactful on the quality of HVAC maintenance through the Policy Delphi survey are outlined in the breakout box below. The respondents were also asked to rank policy options (categorised as: inform; regulate, incentivise) for each issue. The results of this prioritisation exercise are summarised in the breakout box. Overall, the combination of measures with the strongest support from HVAC contractors and facilities managers across the various stages of the HVAC lifecycle included the following:

INFORM

- Provision of template HVAC maintenance contracts for FMs and owners to use when procuring maintenance.
- Provision of lifecycle cost information to FMs and owners (i.e. cost of insufficient maintenance and excessive energy consumption).

REGULATE

- Establishment of a minimum set of standards for HVAC preventative maintenance (inc. inspections, logbooks and schedules), with appropriate compliance mechanisms.
- Implementation of appropriate licensing, with enforcement of penalties for malpractice, for HVAC contractors.

INCENTIVISE

- Provision of incentives to owners for capital upgrades of older systems (and installations) where lifecycle costings have been completed.

This represents a suite of policy options that target multiple stakeholders - HVAC contractors, facilities managers and building owners - and various stages of the HVAC lifecycle. This is illustrated in Section 5 (Figure 3).

This project reports a comprehensive and nuanced range of quantitative and qualitative insights into policy options to improve maintenance practices, grounded in the perspectives of those working at the front line of HVAC energy performance. The findings indicate that a suite of policy options presents the most comprehensive approach to improving the maintenance and management of HVAC systems in the mid-tier sector. The industry recognises a need for better information on the value proposition for improved HVAC maintenance, and guidance on how to implement this through the procurement process. Policies aiming to inform the sector would represent a welcome first step for supporting improved maintenance practices. However, the study showed strong support amongst frontline HVAC professionals for policy interventions that go beyond information provision. This suggests significant additional opportunities to raise HVAC maintenance performance through regulation and incentivisation. Financial incentives, targeted at improving older systems, and particularly regulations designed to raise maintenance standards and ensure said standards are seen as necessary by many in the industry, should be considered as important policy tools to achieve the scale of improvement consistent with current whole of government policy targets (as per the Addendum to the Trajectory for Low Energy Buildings – Existing Buildings and National Energy Productivity Plan).

MID-TIER HVAC MAINTENANCE: KEY ISSUES AND SUGGESTED RESPONSES

ISSUE 1

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 while the impacts of sub-standard maintenance can take many years to become obvious. Because of this, short term fixes are often prioritised.

Suggested response: There was a split between respondents on the best response to this issue. Providing lifecycle cost information to FMs and owners (i.e. cost of insufficient maintenance and excessive energy consumption) was selected by 35% of respondents. Regulation to require mandatory preparation of asset condition audits and asset management plans for HVAC systems in leased buildings was selected by 28%, and incentives for owners to undertake upgrades and installations where lifecycle costings have been completed was recommended by 26%. Relying on MEPS increases to improve system performance over time was only selected by 4% of respondents.

ISSUE 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.

Suggested response: More than half (52%) of respondents recommended regulation to enforce a minimum set of standards for HVAC preventative maintenance (inc. inspections, logbooks and schedules). The provision of template HVAC maintenance contracts for FMs and owners to use when procuring maintenance was recommended by 40%. Very few (4%) recommended incentives to address this issue.

ISSUE 3

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.

Suggested response: The vast majority of respondents (69%) selected regulation to enforce a minimum set of standards for HVAC preventative maintenance (inc. inspections, logbooks and schedules) as the best method to address this issue. Information (i.e. lifecycle cost information to FMs and owners) and incentives (i.e. subsidies for HVAC condition audits or building tuning, including assessment of maintenance completeness) were recommended by 19% and 13% respectively.

ISSUE 4

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.

Suggested response: Incentives and information were relatively evenly selected by respondents. 40% saw incentives to owners for capital upgrades of older systems as the best policy response to this issue, and 38% selected information to FMs and owners regarding lifecycle costs, Regulation to enforce minimum standards for preventative maintenance or mandatory disclosure of building energy performance were selected by 15% and 6% of respondents, respectively.

Further information regarding these, and the other identified key issues, is found in Section 5.

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. It provided a substantial new empirical data source for understanding how the HVAC repair and maintenance workforce engages with buildings and technologies, building owners and tenants, governance authorities and regulators, and with each other through formal institutions, and through informal, everyday working relationships.

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 et al. (2021)*.

This report details findings from a follow-on project that aimed to develop a more detailed empirical understanding of the decision-making processes that characterise the procurement of HVAC management and maintenance services in mid-tier commercial buildings. The project outcome includes a range of policy options mapped against key issues identified across the HVAC maintenance lifecycle.

This report details the findings of these investigations. It is structured as follows:

- Section 2 presents a summary of the main findings form the initial survey for contextual purposes;
- Section 3 – **Methodology** - provides an overview of the mixed methodologies used in the project, including in-depth qualitative interviews and a modified Policy Delphi survey process;
- Section 4 – **Understanding the key issues** - presents an overview of the key issues identified in mid-tier HVAC maintenance, ranked by participants in terms of the impact they have on maintenance quality, and the frequency with which they are encountered. This section also maps the issues onto workflow diagrams, identifying where decisions made during the HVAC maintenance lifecycle have an impact on energy efficiency and system performance in mid-tier buildings.
- Section 5 – **Prioritising policy responses** - presents an overview of how participants prioritise a series of policy options against key issues.

2. SUMMARY OF BETTER WAYS TO WORK SURVEY RESULTS

The following section presents a brief summary of the main findings from the *Better Ways to Work* survey. Full details and analysis can be found in *Carr et al., (2021)*. The survey report presented the results according to three key areas, namely: People, Buildings and Systems, and Maintenances Practices.

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 designer or consultants (16.2%).
- SMEs were the most common enterprise type for contractors (46.8%) and engineers/systems designers (50.8%), whereas facilities managers were predominantly from multi-national enterprises (37.9%), 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. Contractors were engaged equally often by owners and facility mangers (40.4% and 40.5% respectively).

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 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.

3. METHODOLOGY

The *Better Ways to Work* survey provided a comprehensive overview of management and maintenance practices in mid-tier buildings. It also provided a database of over 500 professionals working in the sector who were willing to participate in further in-depth research to better understand the complex issues that inhibit energy performance in mid-tier buildings. This section provides an overview of the methodologies used to gather data for this project, which include:

- Cluster analysis to determine specific areas of interest for further investigation in qualitative interviews;
- Qualitative interviews with HVAC and facilities management professionals in the mid-tier building sector, incorporating in-depth discussion of HVAC maintenance workflow; and
- Modified Policy Delphi survey process with HVAC and facilities management professionals.

CLUSTER ANALYSIS AND QUALITATIVE INTERVIEWS

An initial cluster analysis was undertaken on the responses to the original *Better Ways to Work* survey, with the aim of determining specific areas of interest that warranted further investigation. Response data was grouped using two-step cluster analysis within SPSS, testing multiple variables based on responses to questions on worker profiles, geographic context, role types, HVAC system type, and maintenance practices. Through this process, the research team worked in consultation with DISER to identify four clusters of interest where further research was required to understand how decisions were currently being made that led to either better or poorer energy performance outcomes:

- Cluster 1: Large central HVAC systems that had never been upgraded (suburban and regional contexts)
- Cluster 2: Combination systems, where central and split system HVAC were present in the same building (CBD and regional contexts)
- Cluster 3: 'Best practice' maintenance (preventative; regular upgrades)
- Cluster 4: 'Keep it functioning' maintenance (reactive; prevalence of comfort complaints)

A pool of potential interviewees were purposively selected to ensure a diversity of experience was covered in the interviews. This ensured representation from each cluster group, role type, state location (except NT and Tas) and geographic context (CBD, suburban and regional) as shown in Table 1. In-depth qualitative interviews of approximately 90 minutes were completed with ten (10) respondents, focusing on workflow process and factors that influence decision-making during the maintenance, repair and upgrade lifecycle of HVAC systems. Data provided in these interviews was used to develop draft workflow diagrams, and identify 15 key issues that impact maintenance and performance quality through the typical maintenance and upgrade process flow.

Table 1. Summary of interview participants.

ROLE DESCRIPTION	GEOGRAPHY	STATE	CLUSTER
Facilities Manager	Capital city suburban	Vic + SA	C1
HVAC contractor / works manager	Regional towns	Vic	C3
Facilities Manager	Capital city suburban	Vic	C4
HVAC engineer	All	WA	C4
HVAC contractor	Capital city CBD	NSW	C1
Senior HVAC technician	Capital city CBD	ACT	C2
HVAC contractor	Capital city suburban	SA	C4
HVAC contractor (manager)	Regional towns	QLD	C4
HVAC contractor	Regional towns	NSW	C4
HVAC service manager	All	QLD	C4

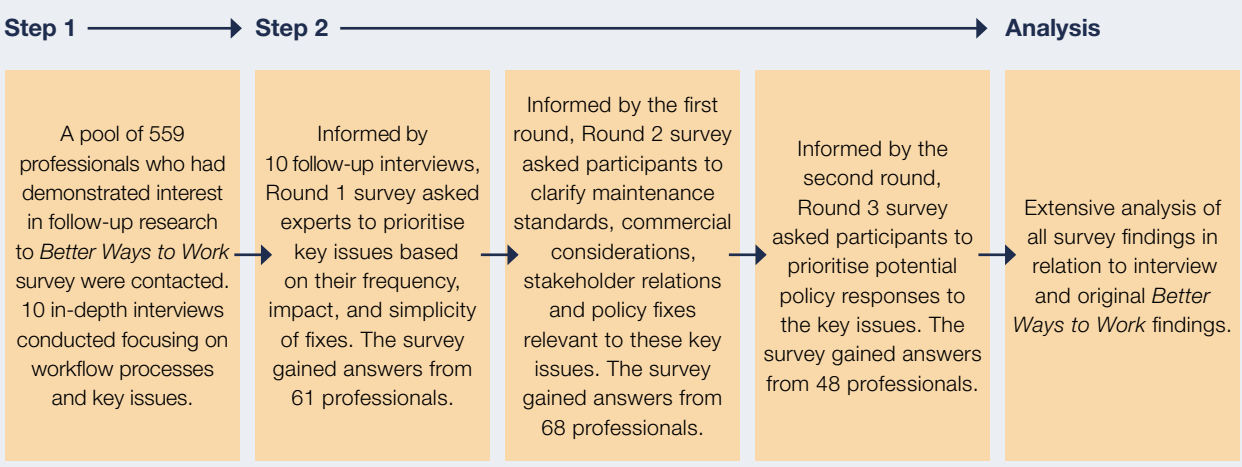
MODIFIED POLICY DELPHI SURVEY PROCESS

To further validate and build on interview findings, a modified Policy Delphi method was used to:

- **Round 1:** prioritise the 15 key issues in terms of their frequency, impact and potential fixes
- **Round 2:** gain further insight on the ways maintenance standards, commercial considerations and stakeholder relations impact on the four key issues that had the most significant impact (identified in Round 1); and
- **Round 3:** prioritise a range of potential policy responses to the nine most significant issues.

In the Policy Delphi participants worked as experts of their own workflow and process, answering a series of three online questionnaires in order to explore a multitude of views and new ideas. The questions for the first survey round were developed based on insights developed during the in-depth qualitative interviews, with the second and third rounds building on the responses received to the previous rounds (see Figure 1).

Figure 1. Modified Delphi process.



DELPHI ROUND 1 – PRIORITISE KEY ISSUES

The first Delphi round developed a list of 15 key issues across HVAC maintenance lifecycle using insights from the *Better Ways to Work* survey and participant interviews. This round asked participants to prioritise these issues in terms of their impact, the frequency with which they were encountered, and the potential for a simple fix.

DELPHI ROUND 2 – UNDERSTANDING THE KEY ISSUES

The second Delphi round focused on better understanding the four key issues that were identified in Round 1 as having the most significant impact. For each of these four issues, questions were asked about what maintenance standards participants used, the commercial considerations at play, and how stakeholder relationships informed maintenance outcomes.

DELPHI ROUND 3 – IDENTIFYING POLICY RESPONSES TO KEY ISSUES

The third and final Delphi round asked participants to prioritise potential policy responses to key issues. At this point the list of issues was expanded from four (in Round 2) to nine. This included all issues that more than 84% of Round 1 respondents identified as having a major impact on maintenance quality, and sought to balance coverage with engagement.

The policy options were selected based on the *Better Ways to Work* Policy Brief, and responses to the Round 2 survey. Policy options were categorised according to three types: 1) Inform; 2) Regulate; and 3) Incentivise. Up to four policy options (along with an 'other' option) were offered against each of the nine issues.

Table 2. Summary of modified Policy Delphi survey respondents.

ROUND	COMPLETE RESPONSES	PARTIAL RESPONSES	TOTAL
Round 1: Prioritising key issues	59	2	61
Round 2: Understanding key issues	50	18	68
Round 3: Identifying policy responses to key issues	46	2	48

4. UNDERSTANDING THE KEY ISSUES IN MID-TIER HVAC MAINTENANCE

The in-depth qualitative interviews with practitioners specifically focused on workflow processes and decision-making that had an impact on HVAC maintenance quality and system performance. This built on existing knowledge of HVAC maintenance in the mid-tier commercial office sector, including data from the *Better Ways to Work* survey and interviews with an expert Advisory Panel appointed to the project in March 2020.

As is well established, this is a large and very diverse sector, with HVAC system performance and maintenance quality occurring across the full spectrum from best practice to barely functioning. This makes it impossible to generalise about the sector, though there is clearly scope for substantial improvement in the quality of HVAC maintenance practices, which will in turn have an impact on energy performance.

Drawing on results of the *Better Ways to Work* survey and interviews with participants with a diversity of experience across the sector, 15 key issues that impact HVAC maintenance quality were identified. The three round modified Policy Delphi surveys tested the validity of these key issues, and then developed a robust and nuanced understanding of their impact on maintenance practices, as presented throughout this report.

Table 3 summarises the 15 key issues, and prioritises them based on their impact on the quality of HVAC maintenance, how frequently the issues are encountered, and a significance ranking (derived by multiplying impact and frequency).

These results show that practically all issues identified are relevant to HVAC professionals. Apart from one issue[1], all issues were frequently encountered by over 70% of respondents, and a significant majority of respondents believed that each of the issues had a major impact on maintenance quality. This provides confidence that these issues are the significant ones in this sector.

The colour coding (yellow/grey/blue) in Table 3 reveals differences in the rankings between the impact and frequency categories, however the significance column shows a relative consistency with the impact ranking. The yellow are the four with the highest impact rank, which were explored in greater detail in the Round 2 survey. The grey are the next five with the highest impact rank. The yellow and grey ranked issues (9 in total) were mapped against potential policy responses in the Round 3 survey (see Section 5). The number of issues that were the focus of different survey rounds was largely determined by practical considerations about length of survey and gaining a useful response. While the rankings are useful for prioritisation, one of the key takeaways from this work is that practically all of the key issues were seen as common and impactful.

Figure 2 maps all 15 key issues across the mid-tier HVAC maintenance lifecycle, from conception of system design to performance evaluations. The numbering key in Figure 2 is replicated in Table 3 to clarify the connection between the two. The 15 key issues are ranked according to impact, being the percentage of respondents who indicated the issue had a major impact on maintenance quality.

The key issues are described in greater detail below, stepping through the maintenance process lifecycle. The focus in this section is on the issues prioritised as having the largest impact on maintenance quality, particularly the maintenance standards, commercial considerations and stakeholder relationships that formed the basis of the Round 2 Delphi survey.

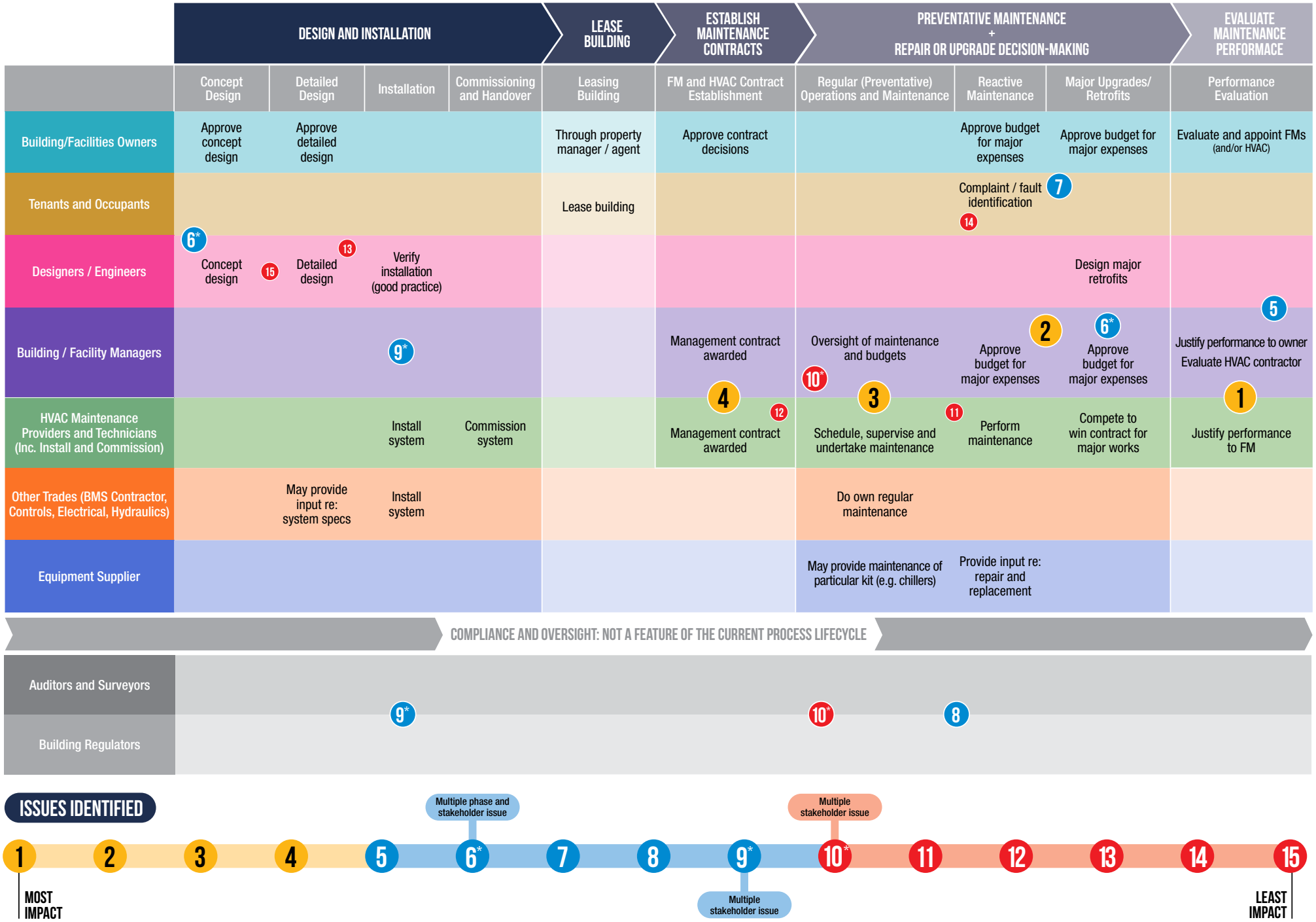
1. *'Perverse influences on design decisions - HVAC system design is influenced by factors other than appropriate specifications or meeting project budget'* – frequently encountered by 44.6% of respondents

Table 3. Key issues impacting the quality of HVAC maintenance in the mid-tier office sector

	SUMMARY OF KEY ISSUE	PHASE	IMPACT: HAS MAJOR IMPACT ON MAINTENANCE QUALITY		FREQUENCY: I FREQUENTLY ENCOUNTER THIS ISSUE		SIGNIFICANCE: IMPACT x FREQ.
			Rank	% Yes	Rank	% Yes	Rank
1	**Job performance is judged on a different timeframe (short) to the impacts of maintenance decisions (long), leading to the prioritization of short-term fixes**	Evaluating maintenance performance	1	93%	7	83%	3
2	**Upfront cost implications of repair or upgrade prioritised over lifecycle cost and system performance**	Repair or upgrade decision-making	2	91%	2	87%	2
3	**Preventative maintenance contracts lack detail regarding expected standards, resulting in conflicting interpretations between contractor and client**	Preventative maintenance practices	3	91%	9	82%	4
4	**The preventative maintenance market is highly competitive and cost driven so it is delivered as a lowest cost service**	Establishing maintenance contracts	4	89%	1	91%	1
5	**FMs' job performance judged on budgets, not lifecycle performance, with potentially adverse impacts on the HVAC system**	Evaluating maintenance performance	5	87%	6	84%	5
6	**Budgets often pre-determined before HVAC professional input, which rule out the best solutions.**	Repair or upgrade decision-making	6	86%	10	80%	8
7	**Split incentives for maintenance decisions, with tenants paying cost of maintenance, but owners paying cost of upgrades.**	Repair or upgrade decision-making	7	85%	4	85%	7
8	**Lack of consequences for malpractice**	Compliance and Oversight	8	85%	5	85%	6
9	**Lack of sufficient oversight of HVAC installation and maintenance quality**	Design & Installation and Compliance and Oversight	9	84%	11	79%	9
10	**FMs are unable to provide appropriate maintenance oversight either due to lack of time, or skills and experience.**	Preventative maintenance practices and Compliance and Oversight	10	81%	12	75%	12
11	**Perverse incentives impacting maintenance decisions about whether to patch repair or upgrade**	Preventative maintenance practices and Repair or upgrade decision-making	11	76%	13	75%	13
12	**Lack of time provided to understand HVAC systems in new buildings or new contracts.**	Establishing maintenance contracts	12	73%	8	83%	11
13	**Lack of detailed project briefs or specifications, particularly in smaller buildings**	Design & Installation	13	70%	3	86%	10
14	**Conflicting priorities between fixing performance or 'fixing' complaints**	Preventative maintenance practices	14	69%	14	70%	14
15	**Perverse influences on design decisions**	Design & Installation	15	58%	15	45%	15

Figure 2 provides a generalised process chart of the overall HVAC maintenance lifecycle in mid-tier commercial office buildings, from conception of system design to performance evaluations. The various stakeholders are represented in rows. The numerous steps across the mid-tier HVAC maintenance lifecycle are presented in the columns at the top of Figure 2. The circles on the figure indicate the location with the process of key issues identified by this research, colour coded to match the key on the left hand side of Table 3. Maintenance processes are grouped by key phases, as shown by the arrows above the process map, with different colours for different phases.

Figure 2. Generalised mid-tier commercial office building HVAC maintenance process lifecycle



The following section provides greater detail about the key issues highlighted in Table 3. It is organised based on the stages of HVAC system lifecycle workflow (as illustrated in Figure 2), moving through:

- Establishing a preventative maintenance contract,
- Working on a preventative maintenance contract,
- HVAC system repair or upgrade decision-making
- Evaluating maintenance performance

This section finishes with i. Design and Installation, and ii. Compliance and Oversight, as lifecycle aspects that sit slightly outside maintenance performance, but have significant influence on maintenance outcomes.

For each of the workflow stages, the most impactful key issue is highlighted, and discussed in detail. We explore the maintenance standards, commercial considerations and relationships that are most relevant to these issues. Other issues that are relevant to each workflow stage are also described.

ESTABLISHING A PREVENTATIVE MAINTENANCE CONTRACT

This workflow stage focuses on when bidding for, or entering in to, a preventative maintenance contract.

Key Issue: The preventative maintenance market is considered to be highly competitive and cost driven.

Overall impact Rank: 4

This issue was ranked 4th in terms of impact on maintenance quality (with 89% agreeing it had a major impact), and 1st in terms of frequency (with 91% of respondents frequently encountering this issue). In the mid-tier sector, contracts are generally priced based on the frequency and level of maintenance for each piece of HVAC equipment in a given system or site, and awarded for multiple years at a time. This makes it quite simple for clients (FMs or building owners) to compare and award contracts based on the most competitive price for what is ostensibly the same service. The implication is that preventative maintenance is often delivered as a lowest cost service, or *"minimum viable product".*

"A lot of the "contracts" are dealt with through the FM, the mechanical contractor obviously has involvement in the process regarding pricing etc. however this is pricing based on a chess board. Win it with minimal/nil margin based on gamble that you will pick up remedial works throughout the term. This is why, for me at least, client relationships are absolute key to making these agreements work for both parties."

RELATIONSHIPS

Preventative maintenance contracts for HVAC are usually initiated by the building owner, or the facility manager on the owner's behalf, with an HVAC contractor engaged to do the work.

STANDARDS

There is little clarity in the industry about the appropriate standards of maintenance required in a preventative maintenance schedule. Industry stakeholders were most likely to quote on a specifically scoped standard of maintenance (21%). Sometimes facility managers (especially if representing some of the larger more well-established organisations) already listed the tasks needing to be completed and had calculated a time given for the job. However, there was a diverse spectrum of understood standards, ranging from what AIRAH would define as best practice (*Minimising lifecycle costs and improve asset condition over its lifespan (as well as complying with Australian Standards – DA19*), to unspecified definitions of maintenance (9%), or simply fixing tenant complaints as they arise (5%).

COMMERCIAL CONSIDERATIONS

Although considered to be very cost driven, winning the contract at any cost was not considered important for most respondents (65% said it was not important). Rather, in their commercial considerations the priorities were seen as creating or strengthening the client relationship (87%), ensuring the standards were met through, for instance, realistically pricing tenders (79%), along with maintaining or building the reputation of the firm they were working for (79%). This was reflected by the survey respondents:

"The relationships created are where the money comes from. There needs to be a relationship built on trust and respect and understanding each-others unique positions as contractor and facilities manager."

"Bidding for and winning work based on integrity and strength of relationships has to be key. This rather than a "win-at-all-costs" approach which only further impacts an already budget driven market."

This would seem to indicate that lowest price contracting was not as prevalent an issue as first appears. However, 20% of respondents indicated they aim for lowest cost in a tender response, and 10% indicated they will bid at a loss to secure work. While this is a minority, if tenders are largely evaluated on price, this can be significant enough to drive a 'race to the bottom'. What many of the more experienced contractors criticised about this was the unreasonable work expectations within the budget and timeframe, also noting that there was always someone less experienced or qualified in the trade willing to do the work to a lesser standard in order to win over the contract.

"Tenders we have priced are all let below the realistic time and function ability against the actual cost. That is to say that they publish a list, then expect (based on own calculations) that that list can be completed in 6 minutes when it's a 20 minute task. Then you point this out and they say "oh well that's the contract, that's the contractors problem" and in reality they are blindly letting contracts that cannot be done for the money, and so the standard doesn't just drop, it falls into the Mariana Trench."*

The **implication** here is that the majority of FMs and HVAC contractors want to prioritise maintenance quality and customer satisfaction, yet find themselves limited by unrealistic commercial pressures. This suggests with appropriate support to ensure minimum standards of maintenance are required or appreciated, the industry is well placed to deliver an improved standard of HVAC maintenance.

OTHER ISSUES IDENTIFIED WHEN ESTABLISHING A PREVENTATIVE MAINTENANCE CONTRACT:

Lack of time provided to understand HVAC systems in buildings (Major impact - 73%, Impact Rank - 12). When starting work on a new building/HVAC system, the amount of time available for contractors to develop a comprehensive understanding of the new system varies. This ranges from the initial maintenance check taking slightly longer with the cost absorbed by the contractors, to having a full system audit included in the contract. Having time for familiarisation with a new system is important for well planned maintenance, however in a lowest cost service contracting environment, this is often left out. This issue was ranked 8th in terms of frequency, although a very high number (83% of respondents) said it was an issue they frequently encountered it.

"There would always have to be that… get familiar with the plant. How does it work? … what makes the chillers turn on? … where's the BMS, what's the log-ins, you know, you would, obviously in that first month have to spend a lot more time on site."

WORKING ON THE PREVENTATIVE MAINTENANCE CONTRACT

This workflow phase focuses on when a preventative maintenance contract is in place and being worked on.

Key Issue: Lack of detail in preventative maintenance contracts about the expected HVAC maintenance standards

Overall impact Rank: 3

While the tendering and contracting process to secure a preventative maintenance contract is important in shaping the work that is carried out, there are subtle changes in expectations and priorities once working on a contract. The lack of detail in preventative maintenance contracts about the expected HVAC maintenance standards was seen as having the third largest impact on maintenance quality. The key issue here is that during tendering, and once working on a preventative maintenance contract, there is frequently a lack of clarity about expected standards of maintenance, for example just specifying *"maintain building to Australian standards"*. This leads to differing interpretations on what has been agreed to between client and contractor, and the often-implicit expectations that a client engages a contractor to keep the system running, whilst a contractor is aware that to get a competitive price they must compromise on the quality of work that can feasibly be delivered.

RELATIONSHIPS

When working on a preventative maintenance contract, the first point of contact for the HVAC contractor is usually the facility manager who overlooks the work and decides what is done. Here, the building owner is also consulted, particularly when required due to the cost or extent of the work. While less common, other trades, engineers and system designers or building compliance regulators are engaged in some circumstances and situations. This emphasises that in general, owners, facilities managers and HVAC contractors are the key stakeholders in HVAC maintenance.

STANDARDS

Aiming to meet explicitly scoped standards was still the most common issue when it comes to working on the preventative maintenance contract, although again only in 21% of cases. There was still a diverse spectrum of understood standards, ranging from best practice (15%) to unspecified understanding of 'standards' (13%). Working to comply with manufacturers' recommendations was almost three times as common as at the contract establishment stage, which is indicative of the greater autonomy HVAC contractors have at this stage of the process.

"No regulation of routine maintenance standards. Too many companies not maintaining systems to Australian standards to keep costs low and win more contracts."

COMMERCIAL CONSIDERATIONS

Performing HVAC maintenance in a way that both strengthens the brand of the firm (85% saw this as important) as well as the relationship with the client (83%) were the most important commercial considerations. However, an additional important consideration was ensuring that any additional breakdown or reactive work that occurs is completed by the preventative maintenance contractor's firm (77%). This adds context to the focus on brand and relationship building, and backs up the general understanding that preventative maintenance contracts are seen as 'loss leaders' with potential losses to be regained through winning ensuing reactive work by being the incumbent contractor.

"Interpretations are an issue as everyone quotes different levels or standards. This is where some contractors are also at fault offering minimal work to get their foot in the door then trying to get the cost back through repairs and breakdowns."

There appears to be clear issues with identifying and defining standards in mid-tier HVAC maintenance, and a lack of common understanding across industry about appropriate standards of HVAC maintenance, and particularly how different standards translate into costs of delivering maintenance and lifecycle costs for HVAC equipment. Industry documents such as DA19 (AIRAH) have attempted to clarify this situation, but this study indicates there is still much work to be done.

OTHER KEY ISSUES IDENTIFIED WHEN WORKING ON A PREVENTATIVE MAINTENANCE CONTRACT:

FMs are unable to provide appropriate maintenance oversight (Major impact - 81%, Impact Rank - 10)
Facilities and property managers often lack the time and/or knowledge to provide appropriate checks or oversight of the preventative maintenance regime. This can result in contractors being unable to discuss complex issues with potential cost implications in a productive manner, or enable cut-price contractors to operate successfully. This issue was ranked 12th in terms of frequency, with 75% of respondents saying it was an issue they frequently encountered it.

"There are rarely quality checks of works by a suitably qualified person."

"Further to this, there is often an unskilled person (tenant or building owner) making a decision about an installation or maintenance program without the required level of information or training required to make such decisions. This is only a small part of the problem and something that could be addressed by the mechanical services industry bodies such as AIRAH providing free courses to FM's, tenants or building owners, or providing template specifications or even providing a service where an installation can be assessed both prior to award of contract and/or at the completion of the project."

Conflicting priorities between fixing performance or 'fixing' complaints (Major impact - 69%, Impact Rank - 14). There are conflicting priorities (in terms of time and budget) between (1) doing repairs and maintenance that makes the HVAC system function properly and (2) fixing issues that the tenants are complaining about. With clients pushing for quick and cheap fixes, this incentivises contractors to make maintenance decisions that may not be in the best long-term interests of the HVAC system performance. This issue was ranked 14th in terms of frequency, with 70% of respondents saying it was an issue they frequently encountered it.

"Qualifications are of a Bunnings standard - so Bunnings is their standard - consequences are I would try to explain a cost-effective well-engineered repair - the reply was can't you just go to Bunnings & buy something to fix it?"

DECIDING WHETHER TO PATCH REPAIR OR UPGRADE THE HVAC SYSTEM

This workflow phase focuses on decision-making when a system or piece of kit is performing poorly, and patch repair or upgraded decisions are being considered.

Key Issue: Repair or upgrade decisions are strongly influenced by the implications of upfront costs on annual budgets, rather than best practice

Overall impact Rank: 2

The key issue identified at this phase of the HVAC lifecycle is that these repair or upgrade decisions are strongly influenced by the implications of upfront costs on annual budgets, rather than best practice approaches of considering overall lifecycle cost and improving system performance throughout its lifespan. This issue was seen as having the 2nd greatest impact on HVAC maintenance quality (91% reported it had a major impact), and was frequently encountered by 87% of respondents.

Decisions regarding whether to patch repair or upgrade components of a HVAC system are critical stages in the HVAC lifecycle, with potentially large implications for future repairs costs and energy usage.

RELATIONSHIPS

Decision-making at this stage is largely driven by the facility manager and/or the building owner. Only half (50%) of the respondents indicated that the HVAC contractor was heavily involved in this decision-making. Depending on the strength of relationships here, the contractor may make recommendations, but the ultimate approval will be made on the client side.

STANDARDS

Despite this being identified as a key issue, at the point of upgrade or repair decisions, the majority of survey respondents say they are making decisions based on **Good practice**[2] (40%) or **Best practice**[3] HVAC maintenance standards (29%).

COMMERCIAL CONSIDERATIONS

Likewise, the most important commercial considerations for repair or upgrade decisions were minimising life-cycle cost (78%), ensuring standards are met (77%), and maintaining or building the brand of the firm (76%). The considerations that were rated least important were those focused on the bottom line (minimising capital expenditure or choosing most profitable option).

These results would appear to indicate that the respondent cohort prioritised benefits to the system, yet experienced frequent frustrations that the ultimate decision-makers, whether that be facility management or building owners, were instead prioritising short-term budgets.

"We just give them all the options. They decide what to spend"

"It's all about upfront costs."

"Most old sites keep old equipment running because of the tax breaks they get from repairing rather than replacing equipment"

"As a service technician I tried to highlight when AC units needed replacement rather than patching up - often the unqualified building administrators would overrule - we were then forced to carry out a patch-up job."

Decision-making regarding repairing or upgrading HVAC equipment or whole systems takes into account a variety of factors, from state of the equipment, expected lifespan, building lifecycle (i.e. will it be sold soon), and any upcoming changes to leasing arrangement. However, it is clear the upfront cost, and impacts on budgets is always the priority. While this is unlikely to change, the industry does not appear to factor in lifecycle costing (in terms of energy usage and maintenance costs) to any significant or sophisticated degree. Where it is a factor, it will often be based on back of the envelope calculations. This frequently leads to systems being patched well beyond their usable lifespan, and performing well below the level they should be.

2. Ensure the systems continue to operate at the design performance over the full operational life (and comply with ASs)'
3. Minimising lifecycle costs and improve asset condition over its lifespan (as well as complying with Australian Standards)

OTHER KEY ISSUES IDENTIFIED AS IMPACTING THE DECISION TO REPAIR OR UPGRADE:

Budgets often pre-determined before HVAC professional input (Major impact - 86%, Impact Rank - 6). 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. This issue was ranked 10th in terms of frequency, with 80% of respondents saying it was an issue they frequently encountered.

"but basically because that budget's set, it's really often setting what type of system they have. And then they will have to bring it down from, let's say the system, which will last 25 years or 30 years… A lot of times it becomes just like for like replacements."

Split incentives for maintenance or upgrades (Major impact - 87%, Impact Rank - 7). Leasing agreements for commercial office spaces will often designate maintenance as the responsibility of tenants, while replacements/upgrades are the responsibility of building owners. Not surprisingly, owners are often keen to avoid major system upgrade or replacement works, whilst tenants don't want to bear the maintenance costs for a system or component that has exceed its lifespan. This creates conflicting priorities, not focused on best practice system maintenance. This issue is a common problem across buildings sectors, and was commonly encountered, ranked 4th in terms of frequency, with 85% of respondents saying it was an issue they frequently encountered.

"This is the one item that gets EVERYONE involved as this is the one that decides who pays. If it remains as general maintenance the tenant would pay, however if it goes to capex then the owner would be paying, so these decisions are not taken lightly by any of the stakeholders and usually gets a lot of people involved that would normally take a back-seat approach" .

Perverse incentives impacting maintenance decisions about whether to patch repair or upgrade (Major impact - 76%, Impact Rank - 11). Many of the key issues indicate that HVAC contractors are generally trying to do the best for their system but are held back by commercial pressures. However, there are situations that can incentivise the opposite, particularly given the role of the preventative maintenance contractor in identifying faults and suggesting solutions. This creates the possibility of commercial considerations influencing maintenance decisions. For example, quoted repair works over a certain price might mean the facility manager must go to an open tender, potentially give an opportunity to a competitor. This could influence a contractor to go with a cheaper, but less optimal repair option to stay below the 'open tender required' price. This issue was ranked 13th in terms of frequency, with 75% of respondents saying it was an issue they frequently encountered.

"Often it is better commercial sense to do a half arsed job so that the repair doesn't go out to tender."

EVALUATING THE MAINTENANCE PERFORMANCE

This workflow phase has a slightly different focus to the others, focusing on decision-making and the impact of how performance is judged on these decisions.

Key Issues: i) Job performance is judged on a short timeframe, while the impacts of maintenance decisions can play out over a long timeframe; and ii) FMs' job performance judged on budgets, not lifecycle performance

Impact Rank: 1 & 5

This was the issue that had the 1st and 5th most important impact on HVAC quality. 87% of respondents said they frequently encountered this issue and 91% agreeing that it had a major impact on the maintenance quality.

These two key issues considered this problem in subtly different ways, but are similar enough to address them both here. At the core, the problem is that performance of both HVAC contractors and facility managers are judged by their respective clients over a short timeframe, relative to the expected life of HVAC systems (and the timeframe over which the impacts of sub-standard maintenance may become apparent). This can lead to judging performance on more easily quantifiable short-term metrics (e.g. budget targets) rather than optimising building HVAC performance of the its lifecycle.

RELATIONSHIPS

The key stakeholders on this issue are facilities managers and building owners. The HVAC performance implication here is that short term fixes are prioritised over better longer-term solutions, either because of the way performance is evaluated, or to fit within budget targets.

PERFORMANCE EVALUATION METRICS

Rather than focus on standards and relationships, the Round 2 survey asked about the most important metrics used to judge job performance.

1. Maintenance performance (equipment performs reliably with minimal or no breakdowns)
2. Cost
3. Timeliness (job completed in expected amount of time, and respond quickly to breakdowns), and
4. Customer satisfaction (i.e. the client thinks I'm doing a good job)

Only a handful of responses indicated that metrics such as energy performance, or lifecycle costing forecasts were relevant to their performance evaluations.

*"Awareness of long term cost benefits rather than sticking the cheapest bandaid on the problem [*is needed*]"*

COMMERCIAL CONSIDERATIONS

The most common drivers behind decisions to pursue short term fixes that weren't in the best long-term interests of the HVAC system were:

- Client's budget is insufficient to do anything else
- Cost influences either time allocated to do work, or choice of equipment
- Decisions are made to fit within annual budget
- Tight timeframes preclude certain options

Respondents didn't think short-term fixes being potentially more profitable was an important consideration.

"I encounter a lot of FMs who try their hardest to make themselves look good by ensuring KPIs are met and spending is at a minimum, and avoid big costly upgrades. Just for the duration of their 12 or 24 month contract so they can get a promotion and leave the problems for the next guy."

The client's focus on budget can easily lead to HVAC contractor compromising on the maintenance work carried out, the time spent and equipment quality, in order to maintain the working relationship. As noted by one of the respondents:

"The problem is most building managers prefer to terminate a contract if it's becoming too expensive & find another company to comply with their standards (Budget)."

The maintenance performance standards against which HVAC contractors and facilities managers are most commonly judged focus on short-term indicators of successful maintenance (i.e. systems are functioning with minimal breakdowns), this can incentivise short-term fixes and patch repairs that may not be in the long-term interests of an efficiently functioning HVAC system. A similar issue is also seen regarding budgets, with short-term focus that is inconsistent with the 25+ year lifespan of a well-maintained HVAC system. This is a difficult issue to resolve or improve, but as this research shows, it is a significant challenge facing the industry.

COMPLIANCE AND OVERSIGHT

This workflow phase focuses on how oversight and compliance checking occurs (or doesn't occur) across HVAC system lifecycles.

Lack of oversight and checks of installation and maintenance work (Agree has a major impact - 84%, Impact Rank - 9). 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, and allows sub-standard HVAC operators to survive in the industry. There are a few issues at work here. On smaller buildings, the HVAC installation may be overseen by a builder and client lacking the knowledge to check the work. In buildings with facilities managers overseeing maintenance, lack of knowledge on the part of facilities managers was a commonly cited issue. Furthermore, as HVAC systems are frequently hidden away and difficult to access, facilities management oversight commonly consists of checking paperwork. These issues combine to create an industry where there is little risk that sub-standard operators will get caught out. This issue was ranked 11th in terms of frequency, with 79% of respondents saying it was an issue they frequently encountered.

"As stated there is minimal quality control on standards"

"what I'm actually trying to say is, I think there needs to be more checks and balances by engineers."

"Fresh air requirements/energy efficiency gets neglected because nobody actually checks to ensure that upgrades meet the NCC [National Construction Code]."

There is a lack of consequences in the industry for malpractice (Agree has a major impact - 85%, Impact Rank - 8). Whether at the installation or maintenance stage of the HVAC process, there is a lack of licensing or a regulator with sufficient powers to punish malpractice. This means that even if poor practices and/or operators are uncovered, there is little to force an improvement in standards, meaning they will continue to occur. This issue was ranked 5th in terms of frequency, with 84% of respondents saying it was an issue they frequently encountered.

"License the HVAC trade nationally with a trade occupational license system. This will squeeze the shonky operators out and increase standards and quality of work"

DESIGN AND INSTALLATION

This workflow phase focuses on the work that occurs before the maintenance phases, when new HVAC systems are designed, installed and commissioned.

Lack of detailed project briefs (Major impact - 70%, Impact Rank - 13). HVAC projects on smaller buildings often lack a detailed project brief or specification, other than saying 'install AC'. This can lead to systems being installed that aren't properly designed or optimised for the building. This issue is very common, it was ranked 3rd in terms of frequency, with 86% of respondents saying it was an issue they frequently encountered. It is a particular issue when combined with other issues such as #9 (lack of oversight) where you commonly have installations and upgrades being overseen by facilities managers and owners without appropriate time or experience to do so.

"Quality of Specifications and Scope of Works documents are usually poor and not clear on requirements"

"the installation of new HVAC equipment and its maintenance more over isn't planned thoroughly enough and checked suitably by consultants, builders, and so called professional installers."

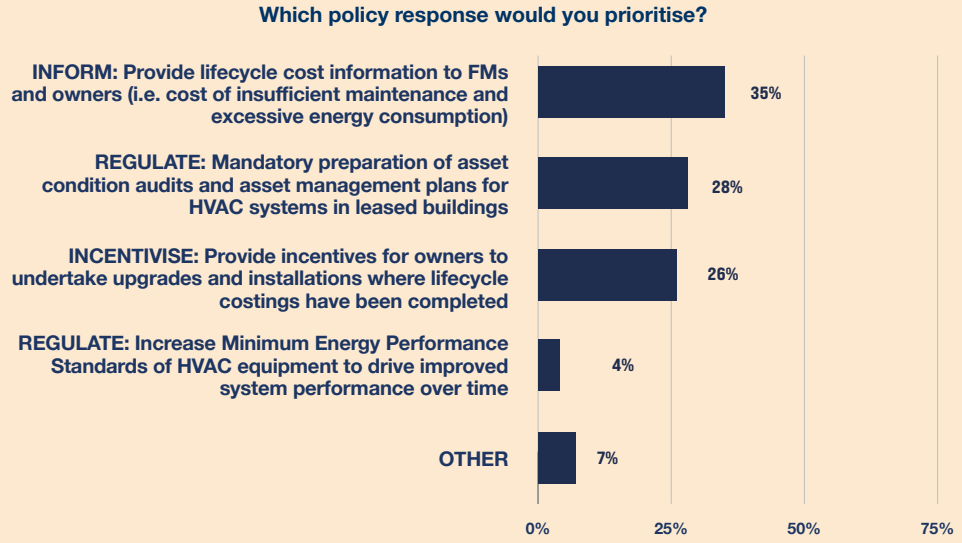
Perverse influences on design decisions (Major impact - 58%, Impact Rank - 15). HVAC system design is influenced by factors other than appropriate specifications or meeting project budget. This might include using stock already in the warehouse, meeting a sales quota on certain kit, or choosing equipment based on profit margin to installer. Often key parts of HVAC systems are manufactured overseas, and can cause significant delays in procuring, so there are various reasons why custom ordering specific equipment may not be the chosen option for certain installs. Less than half the respondents said they frequently encountered this issue (45%), and it was ranked 15th, although it is still encountered commonly enough to be concerning.

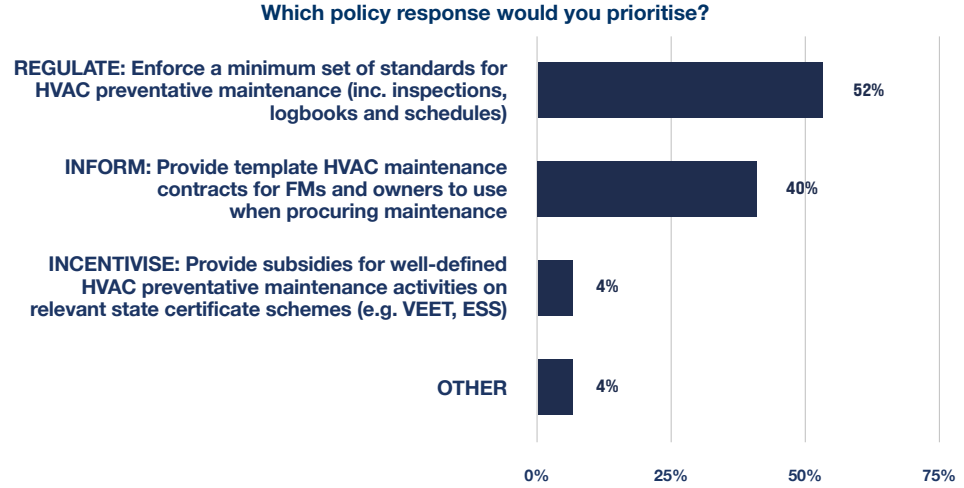
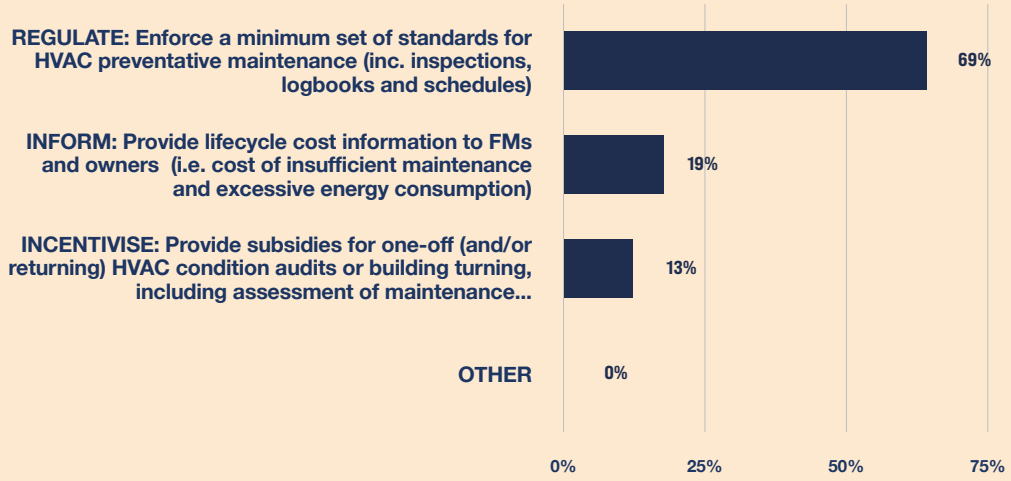
5. MAPPING POLICY OPTIONS AGAINST THE KEY ISSUES IN MID-TIER HVAC MAINTENANCE

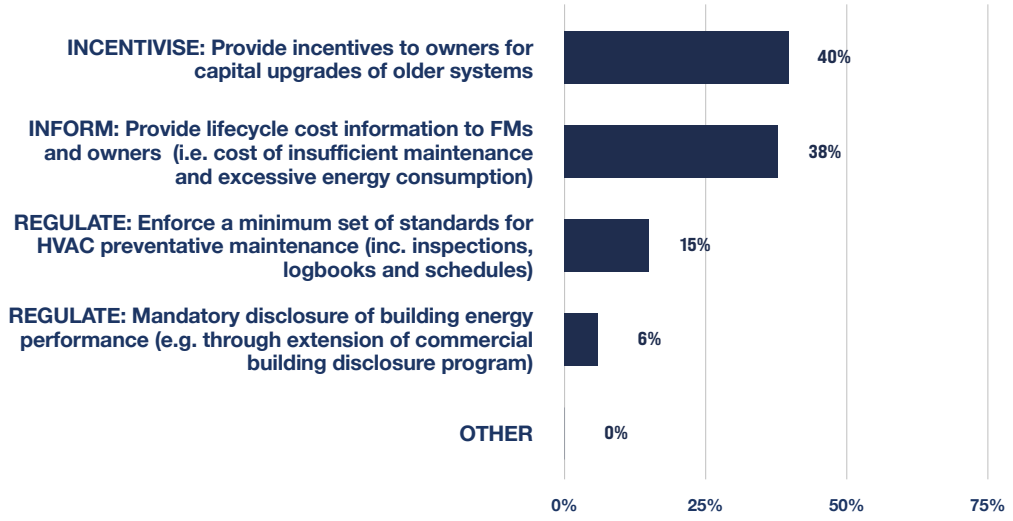
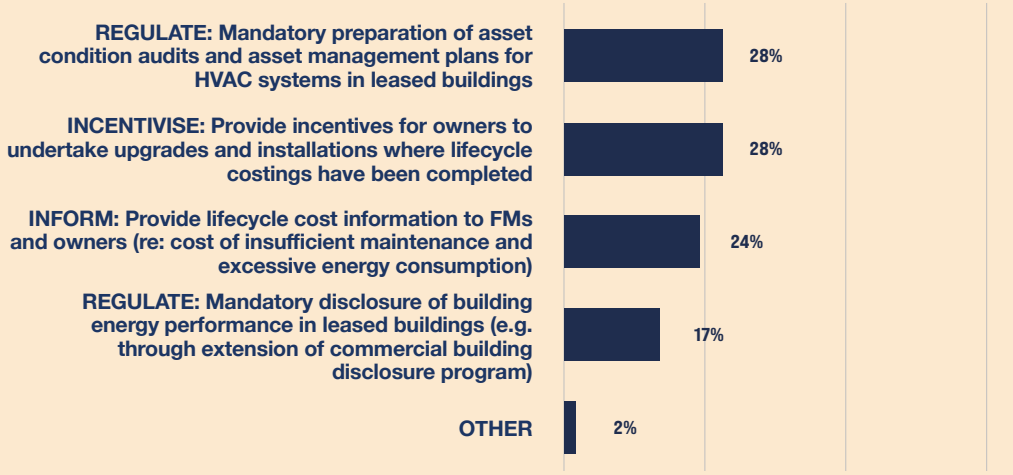
The third and final Policy Delphi round asked participants to prioritise a range of potential policy responses to the key issues identified and ranked in round 1. Policy options were developed based on the Better Ways to Work Policy Brief and refined using responses to the Round 2 survey. Policy options were categorised according to the type of intervention: 1) inform; 2) regulate; or 3) incentivise. Up to four policy options (along with 'other') were listed against each of the nine key issues, with respondents asked to select the policy response they would prioritise in order to address each issue.

The analysis in Table 4 demonstrates a widely held perception within industry that regulation is key to lifting standards of HVAC management and maintenance in mid-tier buildings. However it is clear that many issues would benefit from a multi-pronged approach, where information and incentives also have an important role to play in improving maintenance outcomes. In Round 1 of the Policy Delphi survey, respondents were asked to identify whether there was a 'simple fix' for each of the 15 issues. No issues were identified as having a 'simple fix' by more than 70% of respondents (~50% was much more common), confirming that there is no silver-bullet solution for any of the issues identified. The policy responses outlined in Table 4 below provide a starting point for understanding what combination of initiatives can be used to target specific issues in mid-tier buildings.

Table 4: Prioritising policy options for improving HVAC maintenance in the mid-tier office sector

ISSUE	ANALYSIS OF POLICY OPTIONS	QUALITATIVE INSIGHTS
Issue 1: 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.		*"A fact sheet about the expected asset lifespan and the connection to maintaince will be required for all of the policy summaries above."* *"When owners are driven by asset cost and ongoing maintenance/running costs are paid by the tenant the incentive is always the cheaper up front cost. As you change the MEPS standards, owners—especially small building owners—move towards cheaper systems: cassettes and wall splits replacing ducted systems. Fresh air requirements/ energy efficiency gets neglected because nobody actually checks to ensure that upgrades meet the NCC."* *"all 4 are of equal value"*

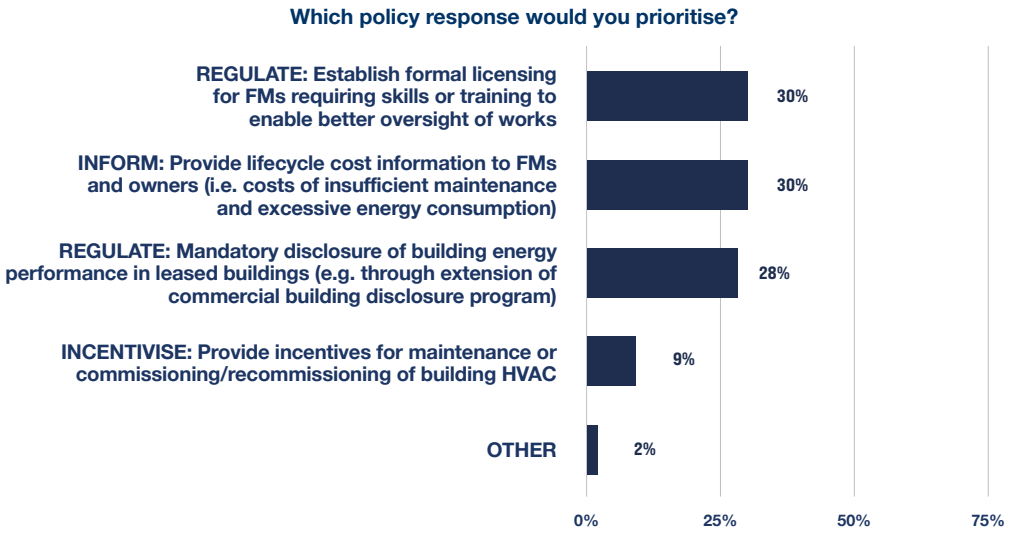
ISSUE	ANALYSIS OF POLICY OPTIONS	QUALITATIVE INSIGHTS
Issue 2: Preventative maintenance contracts lack detail regarding expected standards of HVAC maintenance expectations This can lead to differing interpretations by contractors and clients about what standard of maintenance has been agreed to, and that HVAC contractors are working to meet.		*"We have had DA19 for a long time! Building owners don't care about meeting their maintenance obligations. They won't act till it's regulated!"* *"At the end of the day we can only advise, we can not enforce maintenance spending. The problem is maintenance is a cost to any business, normally a client with a regular maintenance programme in place has little-to-none reactive works… along comes a bean counter and maintenance goes out the window until reactive works increase which can be a long time"*
Issue 3: 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.		*"Regulate, then enforce the rules with random site audits."* *"Similar to last answer owner[s] want quality air and no failures but do not want to pay for the inspection of the item. I have lost quotes on a price basis where we have allowed 12.5 minutes to inspect each piece of equipment, which is bare minimum, and when I pointed this out to the owner that it was not possible to inspect all of the pieces of equipment for the price they accepted they said the other company said they could do it. We have done trials in our workshop and timed the amount of time taken to move from one piece of equipment to the next and carry out minimum inspections, the average depending on the equipment is between 10 and 15 minutes for basic equipment eg fan coils"* *"Log books don't work. Either get lost or are not filled in correctly. Supply inspection/maintenance sheets with invoice."*

ISSUE	ANALYSIS OF POLICY OPTIONS	QUALITATIVE INSIGHTS
Issue 4: 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	**Which policy response would you prioritise?**  	*"show them evidence of poor performing old equipment running costs versus new efficient systems"*
Issue 5: 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.	**Which policy response would you prioritise?**  	*"A combination of all of these would be most effective"*

ISSUE	ANALYSIS OF POLICY OPTIONS	QUALITATIVE INSIGHTS

Issue 6: 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

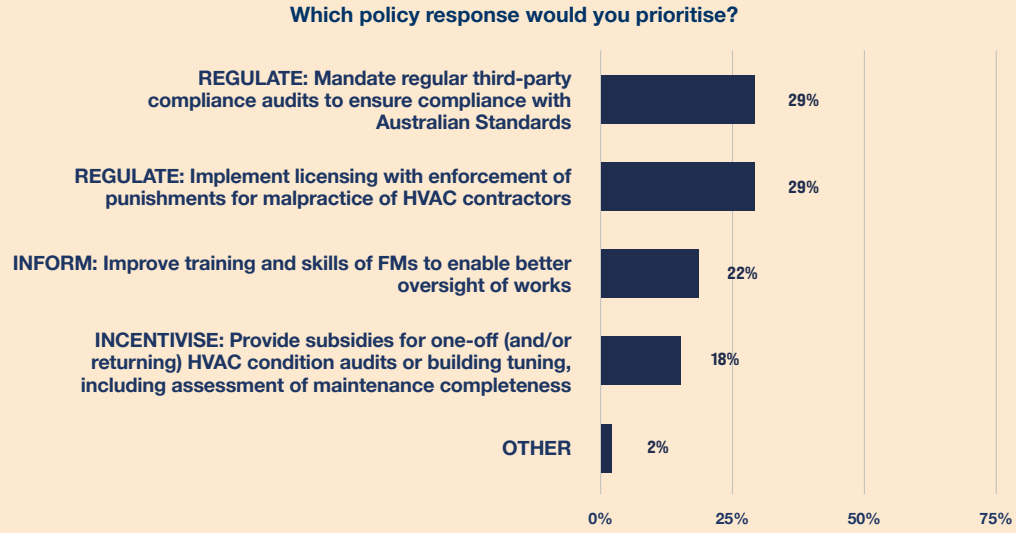


"FMs need to justify to higher management the advantages of proper preventative maintenance. Without HVAC education, they cant justify the cost. As a contractor, We cam explain the value for money, and give the FM'S an argument with their superiors. Down to sales really"

"Building maintenance can be the same as Goverment terms ie during the term of a goverment they keep spending down until the next goverment comes along and they have to spend money to bring systems back to speed"

Issue 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.



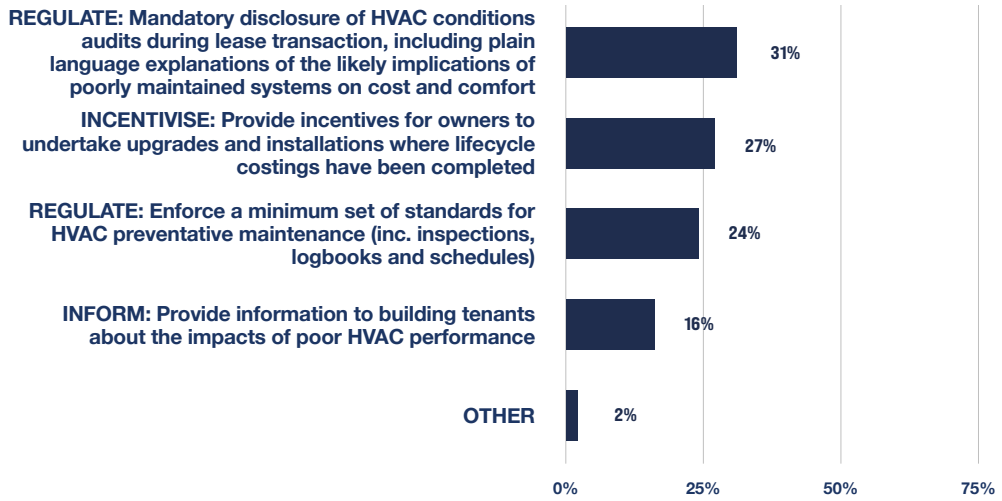
"fines and license cancellation for dodgy operators"

ISSUE	ANALYSIS OF POLICY OPTIONS	QUALITATIVE INSIGHTS

Issue 8: 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.

Which policy response would you prioritise?

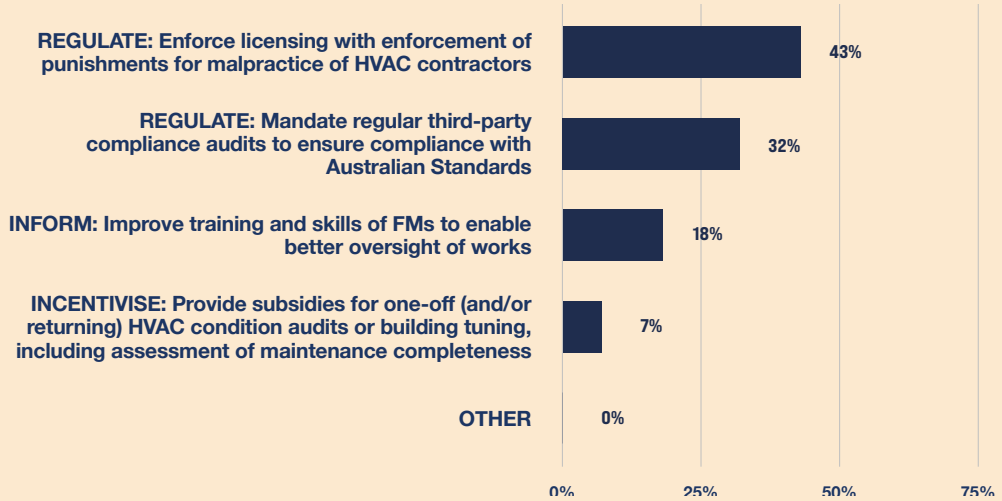


"While the tenants should be held accountable for the standard of maintenance performed, Owners need to be keeping the A/C systems to a minimum performance level"

Issue 9: 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

Which policy response would you prioritise?



"there needs to be a proper regulatory industry lead body to oversee installation standards ie installer to provide a certificate of efficiency and proper installation."

"You will only get rid of the cowboys with regulation"

"Most HVAC professionals are good at what thgey do but there are other trades that are not aware of the implications of there negligence as far as I know you dont have to have a license to carry out maintenace work its not regulated and they never will"

UNDERSTANDING POLICY RESPONSES

The relative support amongst the research participants for the provided policy options for each key issue impacting HVAC performance across the entire lifecycle of a system was detailed in Table 4. Analysis of the responses to the policy options across the all of the issues provided to the participants can provide further insights, and help identify who amongst the stakeholders are targeted, and when in the maintenance lifecycle policies may be most effective.

An overview of all the policy options presented to the research participants is provided in Table 5. It shows the policies organised horizontally according to the three categories of Inform, Regulate and Incentivise. The matrix in the table is also organised vertically according to three sections; issues, stakeholders and timing.

Table 5 can be examined to extrapolate which policy options were suggested as responses to multiple issues, which policy responses target particular stakeholders, and which phases of the HVAC lifecycle is the best target for specific sets of policy options.

The first two columns show the key issues that each policy option was proposed against, the percentage of respondents that supported that policy option/issue combination, and a qualitative assessment of the level of support each option received – strong support, mixed support, and lack of support. The level of support indicated by the participants for each issue was relative to the other proposed options, so comparison across issues is not straightforward. However, as most policies were proposed against multiple issues, much can be gauged by viewing the overall level of support.

The third column indicates the stakeholders that the policy option most directly targets, specifically HVAC contractors, Facilities managers, Tenants and Owners. The last column identifies the timing of the policy intervention in the HVAC lifecycle.

Based on Table 5, it can be seen that all the information focused policies (4/4) received either strong or at least mixed support. The majority of regulation-based policies received strong or mixed support (6/8), whilst a minority of incentive-based policy options received strong or mixed support (2/5).

This overview of the strongly supported policies shows that:

- Incentives such as subsidies for capital upgrades to old equipment (targeted at building owners) had strong support, whether combined with lifecycle costing or not. Other incentive-based policies (incentives for commissioning or targeted preventative maintenance) were not strongly supported.
- There was broad support for many regulation-based policies, and in particular two REGULATE policies – minimum preventative maintenance standards and licensing with penalties for malpractice – had the highest level of support against a single issue. Regulations were targeted largely at HVAC contractors and FMs.
- The information based policies with the strongest support both targeted FMs and Owners, who are generally the decision-makers with control of finances. These were providing lifecycle costing information, and providing template HVAC maintenance contracts.

Overall, the combination of policies with the strongest support included the following:

- **INFORM:** Provide template HVAC maintenance contracts for FMs and owners to use when procuring maintenance
- **INFORM:** Provide lifecycle cost information to FMs and owners (i.e. cost of insufficient maintenance and excessive energy consumption)
- **REGULATE:** Enforce a minimum set of standards for HVAC preventative maintenance (inc. inspections, logbooks and schedules)
- **REGULATE:** Implement licensing with enforcement of penalties for malpractice of HVAC contractors
- **INCENTIVISE:** Provide incentives to owners for capital upgrades of older systems (and installations) where lifecycle costings have been completed.

This represents a suite of policy options that includes information, regulation and incentives. It targets HVAC contractors, facilities managers and building owners, and targets various stages of the HVAC lifecycle from establishment of a preventative maintenance contract. This is illustrated in Figure 3.

This research has clarified the key issues impeding the improvement of HVAC system maintenance and performance in the mid-tier office building sector. Other research conducted as part of this project (see Better Ways to Work: Relevance Beyond the Mid-Tier) indicates that these issues are common across multiple building sectors. Analysis suggests that a suite of policy options may be required to address these important issues. There is a need for better information on the value proposition for improved HVAC maintenance, and guidance on how to implement this through the procurement process. However, it is clear that these alone will not be sufficient to overcome the existing issues. Financial incentives, targeted at improving older systems and, in particular, regulation designed to raise maintenance standards and ensure said standards are followed will also be required to achieve the scale of improvement consistent with current whole of government policy targets (as per the Addendum to the Trajectory for Low Energy Buildings – Existing Buildings and National Energy Productivity Plan). Maximising the impact of any of these initiatives requires a highly skilled workforce across the HVAC maintenance procurement lifecycle. Facilities Managers and HVAC contractors working in the mid-tier will also require targeted training and support to interpret and deliver information, take up relevant incentives, and respond to regulation effectively.

Table 5: Policy options analysis table

>30%	Strong Support	15 – 30%	Mixed Support	<15%	Lack of Support

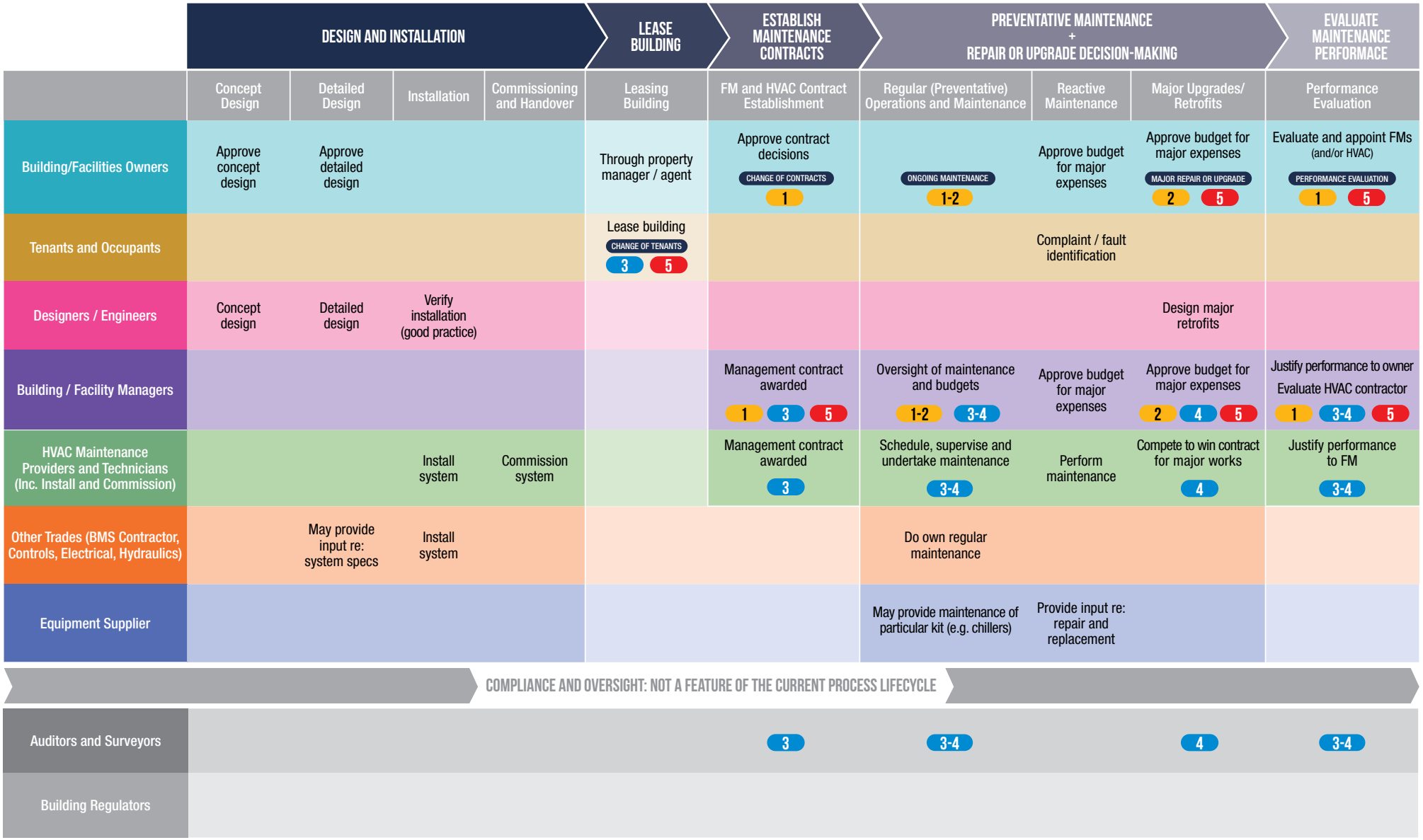
		1. SUPPORT WHEN MATCHED AGAINST KEY ISSUE									2. IMPACTED STAKEHOLDERS					POTENTIAL TIMING					
	Policy | Issue	Issue 1	Issue 2	Issue 3	Issue 4	Issue 5	Issue 6	Issue 7	Issue 8	Issue 9	HVAC contractor	Facilities Manager	Tennant	Owners	Equipment manufacturers	Change of ownership/ maintenance	Point of lease	Training and licensing of workforce	Ongoing operations and maintenance	Major repairs or upgrade	Review of performance or energy
INFORM	**INFORM: Provide template HVAC maintenance contracts for FMs and owners to use when procuring maintenance**		40%									X		X		X			X		
	INFORM: Provide lifecycle cost information to FMs and owners (i.e. cost of insufficient maintenance and excessive energy consumption)	35%		19%	38%	24%	30%					X		X					X	X	X
	INFORM: Improve training and skills of FMs to enable better oversight of works							22%		18%		X						X			
	INFORM: Provide information to building tenants about the impacts of poor HVAC performance								16%				X				X		X		
INCENTIVISE	**INCENTIVISE: Provide incentives to owners for capital upgrades of older systems**				40%									X	X	X	X			X	X
	INCENTIVISE: Provide incentives for owners to undertake upgrades and installations where lifecycle costings have been completed	26%				28%			27%			X		X	X	X	X			X	X
	INCENTIVISE: Provide subsidies for one-off (and/or returning) HVAC condition audits or building tuning, including assessment of maintenance completeness			13%				18%		7%	X	X		X		X	X		X		X
	INCENTIVISE: Provide incentives for maintenance or commissioning/ recommissioning of building HVAC.						9%				X	X		X		X	X		X		X
	INCENTIVISE: Provide subsidies for well-defined HVAC preventative maintenance activities on relevant state certificate schemes (e.g. VEET, ESS).		4%								X	X		X					X		

Table 5: Policy options analysis table (cont.)

>30%	Strong Support	15 – 30%	Mixed Support	<15%	Lack of Support

		1. SUPPORT WHEN MATCHED AGAINST KEY ISSUE									2. IMPACTED STAKEHOLDERS					POTENTIAL TIMING					
	Policy | Issue	**Issue 1**	**Issue 2**	**Issue 3**	**Issue 4**	**Issue 5**	**Issue 6**	**Issue 7**	**Issue 8**	**Issue 9**	**HVAC contractor**	**Facilities Manager**	**Tenant**	**Owners**	**Equipment manufacturers**	**Change of ownership/ maintenance**	**Point of lease**	**Training and licensing of workforce**	**Ongoing operations and maintenance**	**Major repairs or upgrade**	**Review of performance or energy**
REGULATE	**REGULATE: Enforce a minimum set of standards for HVAC preventative maintenance (inc. inspections, logbooks and schedules)**		52%	69%	15%				24%		X	X		X					X		X
	REGULATE: Implement licensing with enforcement of penalties for malpractice of HVAC contractors							29%		43%	X							X	X	X	
	REGULATE: Mandate regular third-party compliance audits to ensure compliance with Australian Standards							29%		32%	X	X		X		X	X		X		
	REGULATE: Mandatory disclosure of HVAC conditions audits during lease transaction, including plain language explanations of the likely implications of poorly maintained systems on cost and comfort.								31%		X	X	X	X			X				
	REGULATE: Mandatory preparation of asset condition audits and asset management plans for HVAC systems in leased buildings	28%				28%					X	X	X	X		X	X		X		
	REGULATE: Establish formal licensing for FMs requiring skills or training to enable better oversight of works.						30%					X						X	X		
	REGULATE: Mandatory disclosure of building energy performance (e.g. through extension of commercial building disclosure program)				6%	17%	28%				X		X	X			X				
	REGULATE: Increase Minimum Energy Performance Standards of HVAC equipment to drive improved system performance over time	4%													X					X	

Figure 3: Policy options with the strongest support from frontline HVAC professionals mapped across mid-tier commercial office building HVAC maintenance process lifecycle



POLICY OPPORTUNITIES

INFORM: 1-2

1. Provide template HVAC maintenance contracts for FMs and owners to use when procuring maintenance
2. Provide lifecycle cost information to FMs and owners (i.e. cost of insufficient maintenance and excessive energy consumption)

REGULATE: 3-4

3. Enforce a minimum set of standards for HVAC preventative maintenance (incl. inspections, logbooks and schedules)
4. Implement licensing with enforcement of penalties for malpractice of HVAC contractors

INCENTIVISE: 5

5. Provide incentives to owners for capital upgrades of older systems (and installations where lifecycle costings have been completed)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