

Climate Control

Summary of Responses

HEATING, VENTILATION, AIR-CONDITIONING AND EFFICIENCY

DISCUSSION PAPER No. 2

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Efficiency Committee



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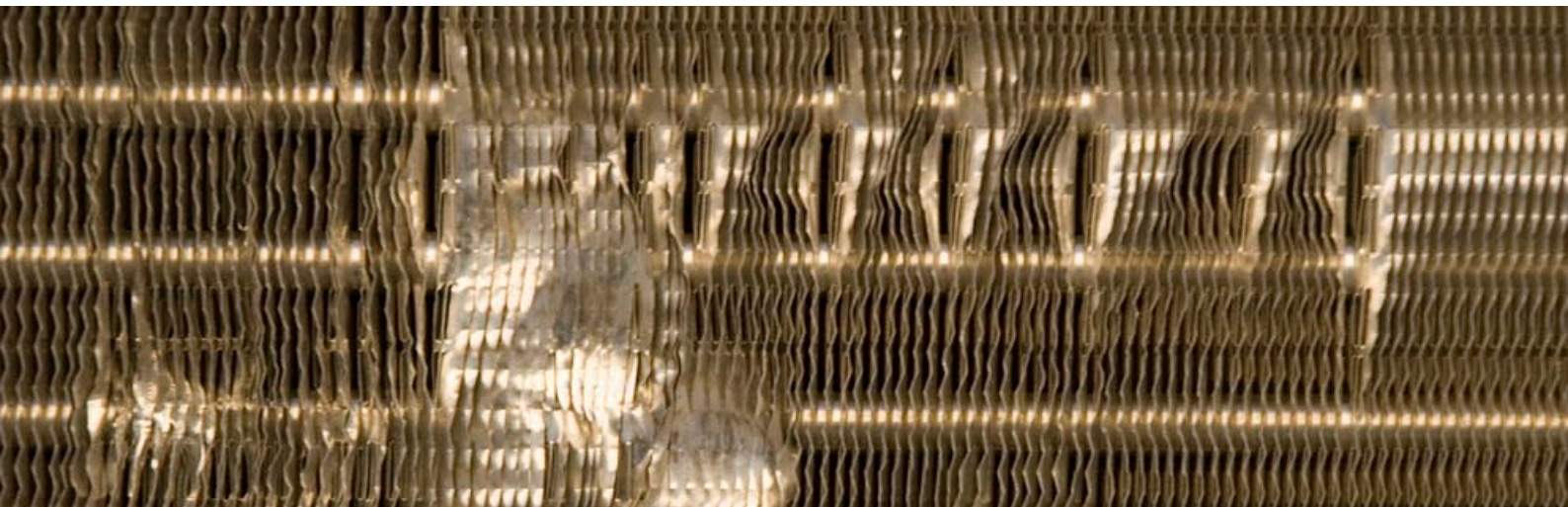
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BACKGROUND

This discussion paper is the second discussion paper produced as part of the HVAC High Efficiency Strategy. It is a milestone along the way to the development of a long term strategy aimed at improving the energy efficiency of heating, ventilation and air conditioning services across Australia.

This content of this paper has been partly extracted from responses to the earlier discussion paper, and should be read in conjunction with that publication, released in September 2005 titled, "Climate Control – Heating, Ventilation, Air Conditioning and Efficiency"¹.

This work is supported by the Equipment Energy Efficiency committee of the Ministerial Council on Energy (<http://www.mce.gov.au/>). All Australian States, Territories, and the Federal Government co-operate through the Ministerial Council on Energy (MCE) on programs to improve the energy efficiency of the Australian economy.

Some of the work of the MCE is carried out by the Equipment Energy Efficiency committee (E₃) which is made up of senior officials from all governments, and supported by a full time secretariat in the Federal Department of Environment and Heritage.

The main programme E₃ delivers began more than a decade ago with an agreement to put energy performance labels on some whitegoods. This initiative has since grown to include the very successful Minimum Energy Performance Standards

(www.energyrating.gov.au) for household appliances and commercial equipment.

The E₃ programme has evolved to become a significant cornerstone of the MCE's National Framework for Energy Efficiency (<http://www.nfee.gov.au/>), an initiative which is expected to save almost 204 million tonnes of greenhouse gas between 2005 and 2020, and yield an economic benefit to Australia of \$4.8 billion by 2020, and \$0.7 billion for the New Zealand economy.

In December 2004 the Ministerial Council agreed to a number of new programs under the NFEE. As well as expanding MEPS to include new equipment and appliances, the new programs include long term strategies aimed at improving the efficiency of cross cutting technologies such as hot water, lighting and HVAC. Cross cutting technologies are those that are employed in almost every sector of the economy. Achieving improvements in the efficiency of these ubiquitous technologies will deliver savings across the economy.

This paper has been published in the context of this broad support from governments to develop programs that will deliver economic, energy and environmental benefits to the Australian community. Comments on this paper are sought to provide input to a draft strategy which will be prepared and released for final comment, before presentation to the Ministerial Council on Energy late in 2006.



It is estimated that by 2010 the energy consumed in HVAC systems across Australia could be responsible for as much as 4% of total national greenhouse gas emissions or as much as 21 million tonnes per annum

¹ The paper referred to can be downloaded from www.energystrategies.com.au/publications

COMMENT INVITED

Comment is invited on any part of this paper by June 30 2006. Responses are particularly welcome that suggest remedies to the obstacles to efficiency identified herein, or that build on or clarify remedies already proposed.

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EXECUTIVE SUMMARY

The major obstacles to highly energy efficient operation of HVAC systems identified by respondents to the discussion paper, "Climate Control - Heating, Ventilation, Air Conditioning and Efficiency," were economic barriers, process failures and skills gaps.

It is particularly noted that there is currently no robust market mechanism to motivate or reward designers and builders for the performance of their buildings in terms of energy use. There is also no clear economic link between investments in energy efficiency by the construction industry and commercial buildings sector, and the beneficiaries of energy efficiency, such as building tenants.

Several responses noted that economic pressures and common industry practices are significant obstacles to higher levels of involvement in the design, manufacture, installation and construction of HVAC systems by the engineers and personnel ultimately charged with commissioning, operating and maintaining those systems.

There is general agreement that the above factors, combined with limited knowledge and skills in segments of the HVAC, construction and facilities management industries, result too often in poor outcomes in design, delivery and operation of HVAC systems.

The majority of responses point to the need for a scheme of best practice for critical points in the supply and operation of HVAC systems, combined with a number of education, training and certification initiatives spread across the entire supply chain, from concept and design of systems, to operation and maintenance of systems.

Recently the importance of commissioning of systems has been widely discussed within the industry. In response to the discussion paper there has been general agreement that a scheme of best practice focussed on commissioning, operation and maintenance of HVAC systems would form an important foundation for a number of initiatives to improve HVAC systems performance.

Central to this scheme would be the development

of national standards of best practice for documentation that will overcome some of the process failures commonly observed, and that can apply to existing as well as new and reconditioned HVAC systems.

Both in support of, and complementary to a scheme of best practice, a considerable number of opportunities are identified to improve the knowledge and skills of, and interaction between, the various segments of the industry and along the entire supply chain.

It is apparent that not all of the obstacles identified can be directly addressed by an industry led scheme of best practice, nor by additional education and training. Nonetheless there are clear opportunities identified for remedies to be applied that should have an appreciable impact on the overall performance of HVAC systems.

INDUSTRY STAKEHOLDERS

Australian Building Codes Board
Air Conditioning and Mechanical Contractors Association
Air Conditioning and Refrigeration Equipment Manufacturers Association
Australian Institute of Building Surveyors
Australian Institute of Refrigeration Air Conditioning and Heating
Australian Property Institute
Australian Refrigeration Council
Australian Sustainable Built Environment Council
Chartered Institute of Building Services Engineers
Energy Networks Association
Facilities Management Association of Australia
Fire Protection Association of Australia
Green Building Council of Australia
Institute of Engineers Australia and Colleges
Master Plumbers Association
National Electrical Contractors Association
Property Council of Australia
Refrigeration and Air Conditioning Contractors Association
Royal Australian Institute of Architects



INTRODUCTION

HVAC systems could be regarded as essential services without which large numbers of buildings would be uninhabitable at certain times of the day.

HVAC systems work - and they work continuously and reliably on an enormous scale across huge areas of built space. Generally they work so well that most people never notice them, nor ever consider the intelligence, science, technology and energy that is employed in delivering fresh temperate air for their comfort.

The purpose of this discussion paper, and of the HVAC High Efficiency Strategy, is to identify cost effective ways of improving the energy performance of an already successful industry and class of technology delivering critical public services.

This summary attempts to build a coherent synthesis of the responses provided by the individuals, companies and organisations listed in the table at **Appendix 1**. The responses were shaped by a series of questions posed in a discussion paper published in September 2005. These questions are reproduced in **Appendix 2**.

The first discussion paper briefly outlined a number of common obstacles to optimal performance of HVAC systems. Many of the responses received were also focussed on the significant obstacles to achieving highly efficient HVAC performance, and the insights bought to the issues warranted their publication. This new material is intended to add more structure to the original proposition and explore potential remedies.

The responses have been synthesised into two topics, 'Obstacles' and 'Remedies'. Several common themes emerge within these two topics.

The list of obstacles to high efficiency performance is not intended to paint a bleak picture of an industry. The obstacles identified here is for the purpose of clarifying the key points at which remedies might be applied to assist in improving the energy and the economic performance of HVAC systems. In achieving those objectives other benefits are highly likely to be captured for all participants in the long

and complex supply chain and decision making processes that result in the outcomes achieved today.

No one obstacle is the major cause of sub-optimal energy performance of HVAC systems. However any combination of the many common and potential obstacles can result in higher energy consumption, higher operating costs and a range of other less than optimal but potentially avoidable economic and energy outcomes.

Material in the 'Remedies' section is diverse in some aspects, and comprehensively uniform in another. The common theme among the responses was a call for training, education and certification of skilled personnel throughout the supply chain.

Where responses have diverged is on the priorities for that training. Beyond the broad consensus for education being a pillar of any future strategy, several respondents provided detailed proposals, parts of which have been reproduced along with the name of the author.

Many respondents provided references to further reading, reports and studies. The contents and conclusions of those referred works are not included here. Many of those materials are extremely useful in relation to particular aspects of the HVAC or construction industry. The purpose of this summary however is not to distil the intelligence of earlier research, but rather to capture a first hand view of the real problems and practical solutions as provided by active participants of the HVAC industry in Australia.

The excerpts from individual responses are published to stimulate discussion on possible elements of the long term strategy being formulated.

Your suggestions are welcome.

THE OBSTACLES

The performance of HVAC systems is the end result of a great number of factors either in isolation or combining throughout the supply chain commencing, in the case of new systems, with the concept for the building, and finishing with the daily maintenance and operation of the system.

All of the responses to the first discussion paper demonstrated a detailed and sophisticated grasp of the range of practical issues facing the industry. Some responses imply that structural and economic problems in the industry were intractable and that several obstacles to improved HVAC performance are effectively insurmountable.

However in this paper 17 broad obstacles have been articulated, listed in the table below in the rough order of their occurrence along the supply chain for HVAC systems. The types of remedies that might be considered to assist overcome these obstacles are indicated.



TABLE 1:

OBSTACLES	INFORMATION CAMPAIGNS	PROCESS CHANGES	EDUCATION TRAINING & CERTIFICATION	NATIONAL SCHEME OF BEST PRACTICE FOR DESIGN, INSTALLATION, COMMISSIONING, OPERATION, MAINTENANCE, & DOCUMENTATION	STANDARDS & CODES	REGULATION
1. LACK OF INITIAL TRAINING AND CPD			X	X	X	
2. DEVELOPERS DRIVING MARKET	X					X
3. INAPPROPRIATE FEE STRUCTURE	X		X	X		
4. POORLY FORMULATED CONCEPT	X		X	X	X	
5. LIMITED DESIGN TIME FRAME	X	X		X		
6. POORLY EXECUTED DESIGN	X	X	X	X	X	
7. CAPITAL COST PRICE DRIVEN DECISIONS				X	X	X
8. CONSTRUCTION SHORTCOMINGS			X	X	X	X
9. POOR INSTALLATION		X	X	X	X	X
10. POOR CONTROLS		X	X	X	X	
11. POOR COMMISSIONING	X	X	X	X	X	X
12. FAILURE TO INTERGRATE ALONG SUPPLY CHAIN	X	X	X	X		
13. POOR MAINTENANCE	X	X	X	X	X	
14. LACK OF DOCUMENTATION	X	X	X	X	X	
15. FAILURE TO UNDERSTAND BUILDING OPERATION	X	X	X	X		
16. OBSTRACLES TO INNOVATIONS	X	X	X			
17. ABSENCE OF PERFORMANCE RELATED MARKET SIGNALS	X					X

OBSTACLES TO OPTIMAL PERFORMANCE OF HVAC SYSTEMS AND POSSIBLE APPLICATION OF REMEDIES

1. Lack of initial training and lack of continuing professional development (CPD) across many relevant trades and professions about HVAC systems design, operation and maintenance
2. Developers driving market
3. Inappropriate fee structure for system designers
4. Poorly formulated concepts for both HVAC systems and for buildings
5. Limited design time frame
6. Poorly executed design
7. Capital cost price driven decisions
8. Construction shortcomings
9. Poor or compromised installation
10. Poor matching of controls design and capabilities with building and HVAC system operation and characteristics
11. Poor commissioning of HVAC systems and associated control systems
12. Failure to integrate design, costing, contracting, construction, control systems and commissioning processes for optimal energy performance outcomes
13. Poor maintenance
14. Lack of, inaccurate or poor quality documentation on 'as-installed' system, commissioning, operation and maintenance of system, inaccurate or poor quality documentation on control system, control modifications, software chain of custody, integration and interoperation protocols with BMS and other software, lack of documentation on building design intent and operating characteristics
15. Failure to understand building, controls and HVAC systems operation by owners, building operators, system maintenance contractors and tenants
16. Obstacles to innovation
17. Absence of performance related market signals

A short outline of the characteristics of these identified obstacles follows.

LACK OF INITIAL TRAINING AND CONTINUING PROFESSIONAL DEVELOPMENT

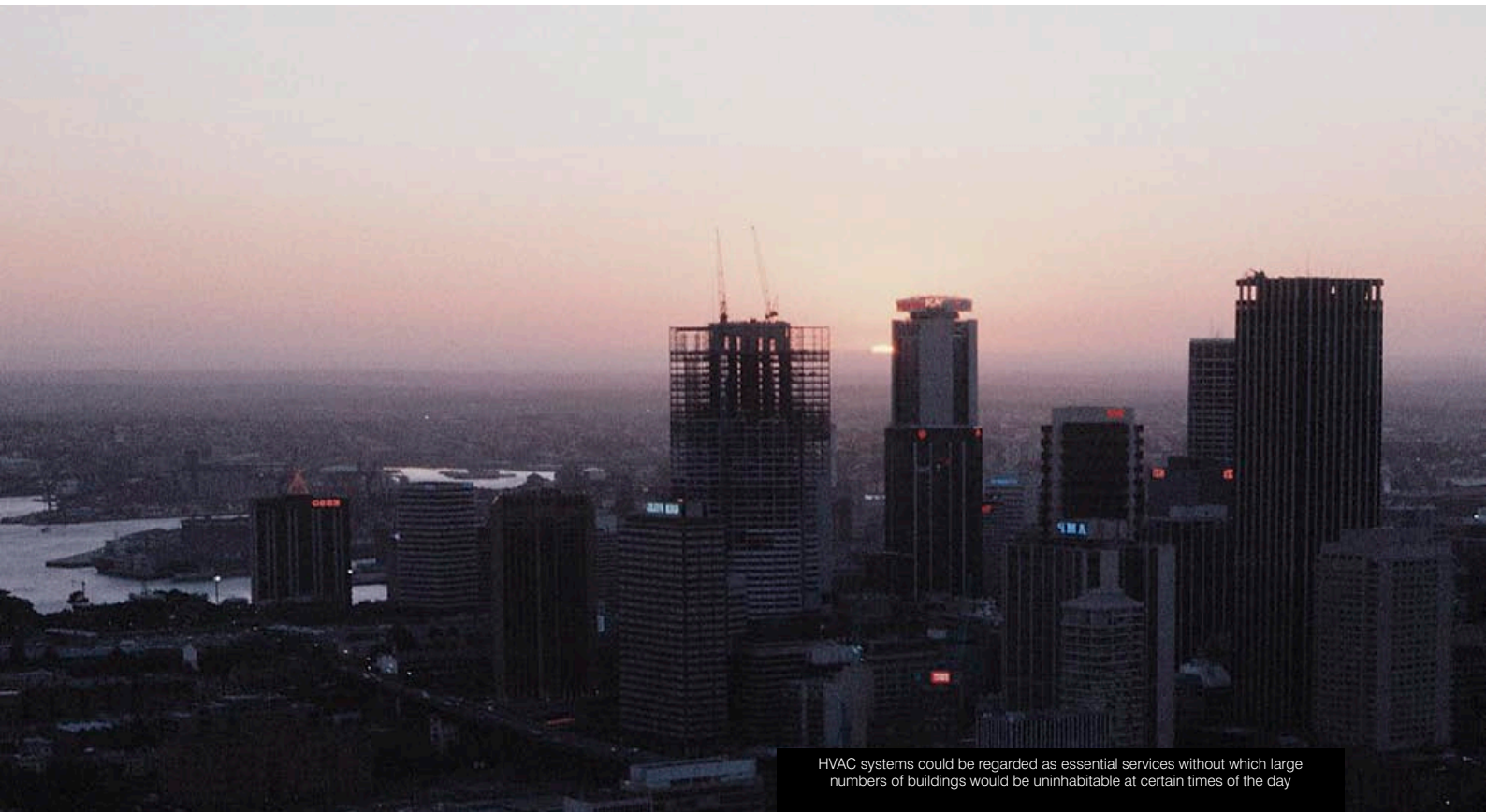
A shortage of relevant, practical training in trade, undergraduate and professional development courses and qualifications was reported by nearly all respondents. This suggests that a large number of industry participants have lower than desirable levels of skills throughout the supply chain, particularly including building owners, facilities managers and tenants.

Efforts by industry bodies, notably AIRAH, and individual practitioners (Ballard and Lane for instance)² to develop and introduce certified training courses have been making progress in the last few years, however without significant resources, and in some cases in the face of wider construction industry apathy.

The National Environmental Balancing Bureau (NEBB), an international standards setting body for commissioning of air conditioning and mechanical services provide training materials and courses which are generally acknowledged as being valuable materials, though not necessarily appropriate to all Australian conditions and situations. The Air Conditioning Mechanical Contractors Association (AMCA) administers the NEBB program in three states (Queensland, Victoria and Tasmania).

There are presently low levels of skills and a lack of opportunities for training for building owners, facilities managers and tenants to learn about the complexities of their building, the mechanical and HVAC services, and the controls. However a national Action Agenda for the Facilities Management Industry released in 2005 provides a strong framework for development of training and certification of system users.

² Since 2003, Alan Ballard, A&R Airconditioning Pty Ltd, and William Z. Lane have developed pilot courses, in association with the MPA and RMIT, that could form the basis of a certificate for Commissioning and Balancing technicians in Australia. Ballard and Lane report they are cognizant of NEBB, TABB and other overseas systems and have considered expanding their existing material to include competencies in Air and Hydronic systems, Energy Management and Auditing, Building Codes and Essential Services. Existing AIRAH developed course materials could be used as the basis for some of these additional competencies.



HVAC systems could be regarded as essential services without which large numbers of buildings would be uninhabitable at certain times of the day

DEVELOPERS DRIVING MARKET

In the majority of cases the developers and financial backers of projects are driving the building market and their prime concern is maximising developer profit. In general there is very little input from other stakeholders at the design stage of projects.

Tenants, for instance, can have some very valuable input to design matters, but typically only those that are considered to be “A grade” tenants have a chance to provide input. The expected release by the Federal Government of requirements for ‘green leases’ during 2006 will at least set higher building performance standards that committed tenants can use as a basis for negotiation, setting performance targets for those developers seeking to secure long leases from premium tenants.

INAPPROPRIATE FEE STRUCTURE

Designers in today’s marketplace are finding themselves working for low fees and competing for jobs on price, not experience. This low fee environment makes the delivery of innovative and energy efficient solutions difficult.

With falling design fees there has been a move to reduce training of younger engineers, and as a result, companies are employing less qualified, less experienced staff, which affects the quality of the resulting designs. With lower design fees, off-the-shelf design solutions are repeatedly used to meet the time constraints that are imposed by low fee budgets.

Contractors forced to compete almost entirely on price use every other possible claim to gain an advantage including promises of system performance. However any forecasts of performance at the tender stage are generally over optimistic and either hard, or impossible to achieve in real life performance.

POORLY FORMULATED CONCEPT

Buildings can be poorly formulated at the conceptual stage, are not often been designed with energy outcomes or optimal climate control characteristics in mind. In the worst cases there is very little that HVAC systems designers can do other than size systems with enough cooling and heating capacity to allow them to compensate for the poor thermal performance of the building shell.

However HVAC systems can also be poorly conceptualized, so that even very well designed buildings are still consuming excessive power to deliver occupant comfort. This is often the outcome when the HVAC systems designer has not properly understood the building design intent which, when combined with the likelihood of low fees and inadequate design time, is almost certain to deliver a sub-optimal system design no matter how well the building shell has been designed.

There is more likelihood of energy efficient solutions being considered, and delivered, if the HVAC system designer is involved at the building concept stage. Poorly formulated concepts for buildings can make it nearly impossible for a designer, under time and fee pressure, to deliver an optimal system design.

LIMITED DESIGN TIME FRAME

The short time frame allowed for the services design stage (conception to tender) limits the possibility of innovative/energy efficient solutions being developed. There is generally not enough time in the project cycle given to explore innovative solutions for projects.

It is possible for designers to specify energy efficient components in the normally available time frames, but to achieve an overall improved holistic system approach takes more time. While there have been significant improvements in the efficiency of individual pieces of equipment (chillers, cooling towers, pumps etc.), there is a great deficiency in the skills required to deliver effective systems integration.

System integration has to be considered very early in the design of any project to achieve maximum energy efficiency potential, but due to lack of education and competence of design engineers this rarely happens. Poor selection of components, in terms of their compatibility is a specific system, compounds poor design and undermines good design.

Developers and builders do not want to pay for what they perceive to be expensive or out of the ordinary systems, so they often do not allow the time or money for energy efficient designs and options to be considered.

A focus almost purely on price considerations also

means that jobs are often re-specified and re-tendered, a process that wastes a lot of time that could otherwise have been spent improving the quality of the design of the system.

Finally designers generally have little or no detailed involvement in a project post the design stage, and would almost never have anything to do with a system they have designed once it is in operation. As such there is little feedback to designers in the construction and installation, commissioning and operation stages that could assist improve their design practices.

CAPITAL COST PRICE DRIVEN OPTIONS

In the event that a designer might provide a more energy efficient design to a client there is every likelihood that it will not be implemented if it is not the least cost option. Builders and developers are mainly interested in short term payback on building projects. As a result of this, the majority of HVAC designs are currently measured on their capital cost value, with full life cycle and operating costs very rarely considered at the design stage. Clients are not always aware of energy efficient design options and their benefits, and hence rarely specify their inclusion in briefs to designers. Innovative design solutions that do get considered are often not adopted due to the initial capital cost forecasts by project managers.

CONSTRUCTION SHORTCOMINGS

Simple and common shortcomings in the quality of construction can have significant adverse impacts on HVAC energy use for the life of a building. The most common problems are encountered with poor joint construction and poor sealing of walls, windows, roof spaces, ceilings and doors all of which can greatly affect the level of outside air infiltration, condensation and conditioned air loss. Quality of



ductwork and ductwork installation can also impact on HVAC performance.

POOR INSTALLATION

Poor installation of well designed, energy efficient systems results in inefficient operation of the systems. There has been a boom in the building industry over recent years and this, coupled with reduced training in the contracting side of the industry, has resulted in a deterioration of skill levels. These skill shortages lead to a lack of understanding of the design intent by the mechanical contractor. Aspects of building construction that affect the operation of the HVAC systems are also not picked up by staff on site (e.g. removal of shading devices, increased window areas, omission of insulation, poor sealing of building etc.).

Today's building practices, in far too many instances,



HVAC systems are robust and will often continue to deliver comfort conditions for long periods even while some components are malfunctioning

preclude the involvement of the design consultant at installation and handover stage of a project. This comes from cost cutting strategies employed by many builders. As a result, poor installations and on site problems are not picked up in the construction phase of a project.

POOR CONTROLS

Compounding all of the above issues is the fact that control systems are not often designed, installed, commissioned or tuned to achieve energy efficient outcomes. Often, due to a number of circumstances such as those set out below, it is simply not possible for a controls contractor to optimize controls for good energy outcomes.

This results from a number of possible factors including:

- + The majority of tender specifications for controls are generally generic and lack description of precise control routines and control logic. Thus the controls contractor is not aware of the full intent of the control system or indeed the design intent of the building and has to submit a price for a control system that is under specified;
- + The controls contractor is not sure how the HVAC system works or what the design intent was meant to be, and therefore adopts standard control routines and set points;
- + Although the controls contractor may be good at controls and making things open and close, the trick is to make them open and close at the right time to meet the optimum performance of the plant. A controls contractor would typically not know the optimum time to stage on / off a chiller for instance, or what temperature of condenser water a chiller prefers, nor many of the other details required to ensure optimal system performance because there is often no effective communication of these vital details along the supply chain from designer, to manufacturer, to installer, to commissioning engineer and then to controls contractor;
- + At practical completion time, typically the critical objective is just to get the air conditioning plant up and running and under some sort of control. This is followed by "how soon can we complete the job and get into the next project" syndrome, for the project team, design consultant, mechanical contractor and the controls contractor.
- + The time frame between practical completion time, actual completion time and the time of full occupancy can be several months. In many instances, there is only a 12 months warranty specified and typically, by the time the project is fully complete and occupied, there is only six months or less in which to actually tune the building and controls. Therefore, typically the building and controls, if tuned at all, only experience a single

winter or a single summer season in which they are tuned.

- There is little or no incentive by the project team, design consultants, mechanical contractor or the controls contractor to actively concentrate on achieving optimum performance of the building, or the air conditioning plant. It is typically not part of their scope of works.

POOR COMMISSIONING

Competent and thorough commissioning and balancing is an essential step in ensuring a designer's intentions are translated into practice, and is crucial to maintaining user comfort and to ensuring the plant is operating as effectively as possible. When done thoroughly, commissioning involves a number of specialist service providers such as control technicians, air balance and water balance technicians, electrical technicians, equipment suppliers and consulting engineers.

The primary objectives of these activities is achieving comfort conditions. Energy considerations can be difficult to balance with that objective, if energy efficiency is considered at all.

Commissioning, coming as it does at the very end of the building program, is often compromised by extreme time pressure. Enough time is rarely allowed for thorough commissioning. Too many times clients fail to understand, or simply do not know or care, how important proper commissioning is to their system and building performance.

There is a general lack of communication between designers, who may not understand or get involved in the commissioning process, and the commissioning personnel who may not fully understand the way in which the design is intended to operate.

There is often very little budget at the end of a project for sufficient commissioning to be undertaken involving close attention to detail and spot checks.

Seasonal recommissioning, if ever conducted, generally focuses on achieving comfort conditions not optimal efficiency. For energy outcomes to become a major objective of commissioning will require some substantial changes in the processes presently

employed, and tasks undertaken, when systems are being commissioned.

FAILURE TO INTEGRATE DESIGN, COSTING, CONSTRUCTION, INSTALLATION, COMMISSIONING, CONTROLS AND OPERATION/MAINTENANCE PROCESSES FOR OPTIMAL PERFORMANCE OUTCOMES

Significant improvements in delivery of highly efficient systems could be achieved by taking an integrated approach to the design, manufacture, installation, commissioning, operation and maintenance of HVAC systems.

By and large there is no involvement in the design stage by manufacturers of system components, by installers, by control systems contractors and by commissioning engineers.

Given this reality there is little chance of those who have to operate and maintain HVAC systems understanding much of the chain of decisions that have gone into the systems that they have to run.

Lowest cost construction programs have the effect of excluding the involvement of;

- Design engineers in contractor selection,
- Design engineers in plant commissioning and testing at the factory for compliance with design specifications,
- Building commissioning experts, installation contractors and controls contractors in review of designs,
- Commissioning experts in review of construction and installation progress
- Commissioning experts in design of control systems.

POOR MAINTENANCE

Poor maintenance is one of the major contributing factors to inefficient energy use in HVAC systems. Buildings are not static - systems break down, become less effective, go out of calibration. Continuous tuning is required to optimise system performance.

An absence of, or infrequent maintenance, is a serious issue from the point of view of energy use. HVAC systems are both relatively complex in actual operation, and very resilient. In other words a significant malfunction in part of the system can generally be compensated for by other components to still deliver required comfort conditions. As such while comfort conditions can be maintained, systems can be running extremely inefficiently from an energy consumption point of view and building occupants will not notice.

One of the other main factors, cited a number of times, is the unwillingness of some owners to spend money on



maintenance. This results in the commonly observed phenomena of plants falling into states of considerable disrepair, systems operating extremely inefficiently for long periods, sometimes years, and work only being done when absolutely necessary because of mechanical breakdown or a failure to deliver comfort conditions is experienced.

The fact that there is no accepted benchmarks that tie maintenance to system performance leads maintenance programs being driven largely by the cost of maintenance rather than maintenance being part of the economic performance of a building.

During commissioning of a building's air conditioning system a number of specialist services are employed. Yet once the building is out of the defects liability period, more often than not, a service contract is let to a single mechanical services contractor who is expected to maintain all of the specialist service tasks.

In reality servicing is usually delegated to one technician in a maintenance company who will most likely have

had no involvement in the commissioning. However he is expected to be competent in all the specialist areas together with understanding and delivery of the basic mechanical service maintenance requirements. The demands on this individual are normally beyond one person's capabilities and short cuts are regularly taken in servicing and maintenance that result in energy performance degradation.

Furthermore it is often observed that technicians whose task it is to service and maintain plant such as chillers, boiler, pumps, fans and filters find it easier to expend their allocated or available service hours at the building management systems (BMS) work station 'tweaking' controls rather than conducting actual component service work.

Hence the building's owner loses twice as follows;

- Service is not performed satisfactorily and system component operation and life suffer,
- In the process of 'tweaking' or adjusting control points many, energy management strategies are bypassed, overridden or disabled and energy consumption increases.

Typically the maintenance contractor will only engage the controls contractor when there is a problem that they can't handle and this often leads to the control system becoming corrupt with modified set points, plant manually turned on / off, etc. The scope of the maintenance contract does not (typically) include scheduled (monthly) checks and monitoring of the operation of the air conditioning by the controls contractor, or the provision of a report to indicate how the building is performing and where it could be improved. As such once a control system has been corrupted, or systems set to operate poorly from an energy point of view, it can be a very long time before anyone competent enough to identify or analyse the problem gets to look at the controls set up.

LACK OF DOCUMENTATION ON HVAC SYSTEM, ON CONTROLS AND ON BUILDING DESIGN INTENT AND OPERATING CHARACTERISTICS

During construction and installation of HVAC systems problems are created by uncontrolled changes to the original HVAC system drawings and specifications by building contractors and subcontractors. This results in the widely observed failure to deliver 'as installed' drawings to a commissioning engineer.

The problems are then compounded because operations and maintenance manuals are often incomplete or simply incorrect if they do not accurately reflect the system as installed.

Documentation on the design and integration of control systems is also often very poor, providing very little or no guidance as to how the control systems interact (or conflict) with other parts of the building management system, and often little documentation on how the control system may have been customized to take advantage of or counteract building fabric or interior design characteristics and performance.

Poor handover of new buildings to users, including insufficient guidance on building operation and characteristics, and incomplete operating and maintenance manuals, is a significant contributor to poor operation of buildings.

This can further compound a general lack of understanding of the design intent by building owners and maintenance contractors. As such building tenancy and use patterns can often be working against the original design parameters.

FAILURE TO UNDERSTAND BUILDING OPERATION

Too often buildings are operated by personnel either without a high degree of training or simply without sufficient understanding of the complexities of the individual building, the building fabric, patterns of use and operation, the building services and the controls.

For instance there is a general lack of appreciation that HVAC systems should be subject to a continuous maintenance, tuning and commissioning regimes.

A commonly observed example of poor understanding of the operation of buildings and capabilities of systems, combined with either poor controls or lack of skills available to operate controls, is the number of systems that run for long hours when buildings are not occupied or only partially occupied.

OBSTACLES TO INNOVATION

There is a lot of new and energy efficient technology

available at both component level and in whole systems. However the industry is struggling to keep up to speed with what works, and in what situations new technology is best employed. Lack of time to research new technologies and systems is one major factor, but there is also a general lack of expertise about how existing and commonly employed technology work, so the understanding of how new technology works proves increasingly difficult for many.

A lot of overseas technology is simply shunned on the pretext that it is not suitable for the Australian climate without it having really been tried and tested. At the same time independently evaluated (vendor independent) case studies of new components and systems in operation are relatively rare and difficult to find, or lack sufficient detailed evaluation to analyse for application to new or existing buildings.

Uptake of innovation is hampered by the general lack of investment or requirements for continuing professional development in the construction and HVAC industries.



HVAC systems are already regarded as one of the most risky aspect of a construction program from the point of view of potential for time delays and cost blow outs, innovation is often not welcome.

ABSENCE OF PERFORMANCE RELATED MARKET SIGNALS

The lack of a clear link between investments in energy efficiency by the construction industry and commercial buildings sector, and the beneficiaries of energy efficiency is a significant obstacle to market support for the efficient use of energy.

There is presently no robust mechanism commonly employed in the market to reward or penalize building designers and constructors for the performance of the final product in terms of either energy use, comfort or usability (ie ease of maintenance access, quality of documentation).

Despite it becoming more common for building designers to employ energy models to predict energy use of their buildings³ while still on paper, once a building is physically complete, there is no incentive for designers or builders to

stay around to see how it actually performs, thus failing to either pass on their insights to owners/tenants, or to take effective experiences of operational outcomes forward into their next project.

While more buildings are now having energy star ratings completed to provide some indication of the expected performance of the building, there is no requirement to have that rating done. Nor are those few buildings that do have star ratings likely to be reviewed to ensure that the post occupancy performance bears much relationship to the original base building rating.

Further, while recently developed rating systems provides owners and builders with some ability to rate the expected performance of office buildings, currently no method or requirement exists for energy rating buildings such as shopping centres, hotels, hospitals, schools, police stations, military bases, industrial sites and others.

Ultimately the lack of market signals rewarding optimal building or HVAC system energy performance are underpinned by the relatively low energy costs enjoyed in Australia. While maximum demand charges are applied to commercial operations and provide some signals about peak use, this is a blunt instrument, and in most cases still not that costly that it warrants a great deal of attention to the causes.

Time of use charges are being applied in more of the market and they will assist alert consumers to costs of energy at times of peak load. However as a general observation, there is rarely extensive sub-metering for electricity, gas and water consumption within buildings. There is generally insufficient break out metering to segregate air conditioning, lighting lifts, and general power consumption. With new buildings extra metering is more common.



³There is a deal of skepticism about the reliability of results of energy modeling programs. A leading expert in energy modeling, Dr Paul Bannister, suggests that, while in the hands of experienced and competent operators energy modeling is a valuable exercise, “most simulation models fall seriously short in their ability to represent the full complexity of large HVAC systems, meaning that any co-incidence of results is arguably fortuitous, rather than intended.” Further, the results of simulations, “will tend to underpredict the HVAC energy use by comparison to the chaos that is actual operation.” Commonly used modelling tools are designed to emulate peak performance in order to allow sizing of equipment, not so much to predict annual consumption data. The value of relying on models for predicting energy performance is questionable.

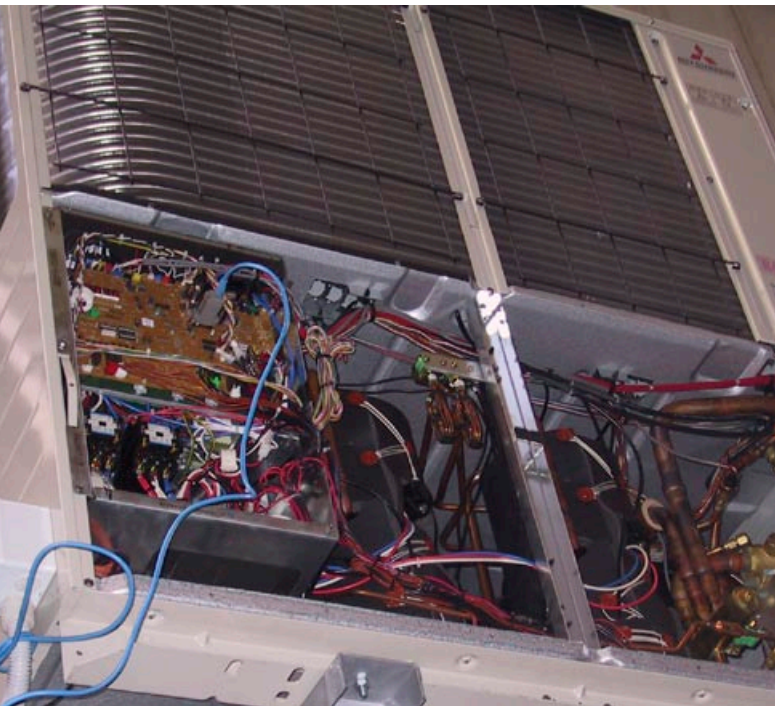
7. REMEDIES

However in most existing buildings metering is just sufficient to allow owners to pass on tenant costs and has not been designed and installed with the purpose of providing much insight to the energy performance of critical aspects of the building systems.

As outlined in **Table 1** the range of possible remedies include information campaigns, process changes, education and training, schemes of best practice, standards and codes and possibly regulation.

The brief overview below of possible remedies to the obstacles identified is not intended to be a comprehensive response to the raft of issues that need attention. Rather this overview, and the extracts from individual responses, is intended to spark readers imaginations about what is possible, practical or desirable in a long term strategy.

The Industry Steering Group, who have overseen the consultation process to date, has begun drafting a comprehensive and broadly based 10 year strategy to address the obstacles identified. That strategy will be built around a series of 3 year workplans. It is intended to draft the first of these three year workplans in some detail in the months ahead. Any of the ideas set out below could be the seed for a significant project within that plan. Any ideas you may have to address any of the obstacles identified, or any comment you may have on the ideas published below are welcome in this process.



QUALITY MARKS, TRAINING, EDUCATION AND ACCREDITATION

Training, education, continuing professional development and public communications activities are referred to throughout many of the responses. Some of the detailed proposals are included in the extracts from individual respondents below.

However the main point is that everyone agrees, investment in widespread training and education has to be a major pillar of any future strategy.

Opportunities for training and education are not limited to the traditional providers but rather there are many specialised areas that could be delivered by RTOs and introduced into the Australian Qualification Framework.

Respondents report that many areas of the industry, and work forces involved in the supply and operation



of systems, are crying out for training, certification and transferable qualifications.

COMMISSIONING, OPERATION AND MAINTENANCE

Australian commissioning standards need to be developed and implemented that require and provide for:

- Involvement of the commissioning engineer and other expert service providers such as control system engineers, in the development of the system from the early stages of design and throughout the supply chain thereafter;
- Comprehensive system documentation – starting at the concept and design stage, and delivered into the commissioning process and then reporting on the commissioning itself;



Ongoing efficiency relies on quality maintenance personnel, systems and procedures. Maintenance personnel are often hobbled by incomplete or inaccurate system and controls documentation.

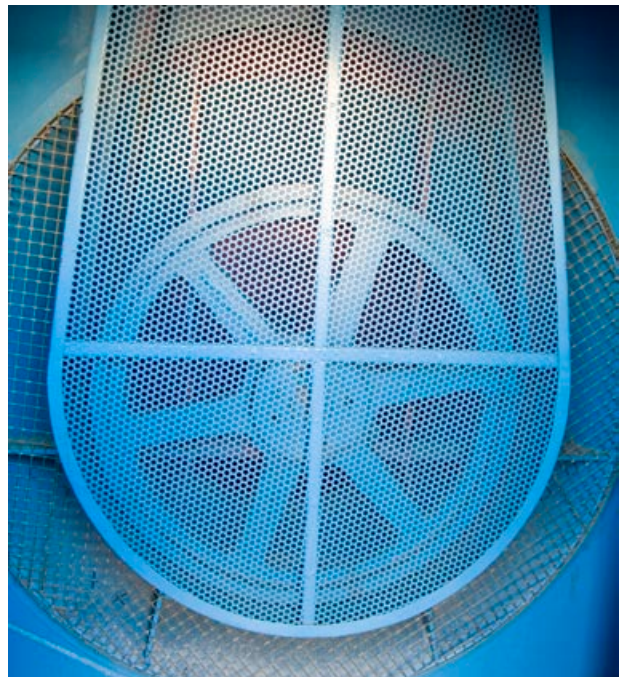
- Verifiable and comprehensive commissioning performance measures that can be used as baseline references for later tuning and measurement of the system post occupancy, as part of routine maintenance performance assessments and post any system refurbishments or alterations.

HVAC COMMISSIONING TECHNICIANS AND ENGINEERS NEED TO BE TRAINED AND PROPERLY ACCREDITED.

DOCUMENTATION STANDARDS FOR BUILDINGS AND ALL SYSTEMS

The creation of standards requiring quality assured documentation delivered by the commissioning engineer should provide a documentary baseline for the continuing operation and maintenance of HVAC systems. The same standard of documentation can be developed for refitting and maintenance of existing HVAC systems.

Facilities managers, maintenance and controls contractors, will all have a significant role in maintaining the documentation throughout the life of the system. These specialists and professionals will require some training in the management and fulfillment of the documentation standards. Providing training and accreditation to these work forces, verifying their capabilities in fulfillment and QA of new standards of building documentation, will then support the development of improved maintenance and operational processes and documentation for existing buildings.



EXTRACTS FROM INDIVIDUAL RESPONDENTS AND SOME OF THE SOLUTIONS PROPOSED. FOR MORE DETAILS ON THESE RESPONDENTS SEE APPENDIX 1.

AYNSLEY

Particularly concerned about the statements in Section 5.1: Human Comfort, of the Climate Control discussion paper, and the lack of any mention of air movement in summer, stratification in winter and the comment about optimal air temperatures being between 21°C and 25°C. He believes that this is an inappropriately narrow range of comfort for Australia and contends that 'natural' and 'hybrid' ventilation and adaptive strategies must be promoted to increase tolerance for a wider range of comfort conditions.

"To save heating and cooling energy then there needs to be more discussion of the potential of indoor air movement in reducing energy use while maintaining thermal comfort. Significant savings can be achieved using energy-efficient circulator fans for indoor air movement. Both de-stratification during winter heating and local air movement during summer can be effective in increasing the energy efficiency of HVAC systems (Aynsley, 2005a). The current version of ANSI/ASHRAE Standard 55-2004 provides guidance in Figure 5.2.3 on how summer increases in thermostat settings can be offset by increasing local air movement."

Includes succinct and lateral answers to the individual questions.

BATHISH

The information most often missing that would allow management or maintenance staff to assess and analyse energy performance and implement improved energy management are:

Real time Key Energy Performance Indicators, such as Watts/m² and KWh/m² for lighting and HVAC end-uses, COP of HVAC and status of key HVAC elements. Availability of such information would allow the management and maintenance staff to timely intervenes and take the necessary actions to stop the deterioration of building energy performance.

In my view the strategies that likely to be most effective for improving energy efficiency of HVAC systems are:

A ~ FOR EXISTING BUILDING:

- Adopting compulsory Energy Efficiency Building Star scheme.
- Raising the energy efficiency awareness among building operators, management and occupants.

B ~ FOR NEW BUILDINGS ON THE DRAWING BOARDS OR BEING CONSTRUCTED:

- Adopting minimum energy performance index.
- Adopting compulsory Energy Efficiency Building Star scheme.
- Raising the energy efficiency awareness among building developers, owners and future occupants.



HANNA AND GREEN

ELECTRICAL COLLEGE BOARD, IEAUST

Energy Modelling

It should be noted that modeling of buildings was not widely used prior to about 2000. Better results are available in terms of optimizing building performance by monitoring energy use for at least 18 months after commissioning or upgrading systems and by ensuring systems are in place for effective recording of operational performance.

Technicians need to have a holistic knowledge of the AC system and how the adjustment of one part of their automated control systems affects other parts of the AC.

Blending of Mechanical and Electrical competencies and specialties for Building Services Engineering as it is presently most operators have predominantly one or the other.

Management need to have periodical recording of operational performance data together with local environmental changes and compare them against specifications. Such data need to be made available to manufacturers for performance feedback.

If reality has it that energy efficiency is primarily for community benefit then inducements by Government through Community Service Obligation Grant/benefits to building owners should be a priority strategy for Government.

Strategies for new buildings on the drawing board

Passive Design

Shading

Materials

Natural Ventilation

Natural Lighting



GROPPENBACHER

Some thoughts on how to improve the links in the HVAC cycle from concept to handover:

- Link the investment to the beneficiary of the investment. This is particularly hard in speculative buildings and easier as it goes towards owner built and occupied premises
- More fully document the process from concept through to handover
- If changes are made as the process goes forward ensure the effects on the HVAC system performance and energy consumption are quantified so a more informed decision can be made

STRATEGIES TO IMPROVE ENERGY PERFORMANCE OF HVAC SYSTEMS:

♦ Existing buildings:

- i. Improve skills of people responsible for the operation of the HVAC systems thermal and energy performance
- ii. Improve the existing documentation of the operation and maintenance procedures/objectives of the HVAC systems
- iii. Raise the level of involvement by upper management in the financial benefits to be gained by running more efficient HVAC systems
- iv. For refurbishment projects take advantage of the opportunity to redefine the HVAC system in total and to look for improvements in the system rather than just change some components of the system

Consider incentives such as:

1. Accelerated depreciation for upgrading to more efficient systems. Base these on system outcomes and not just component upgrades
2. Rebates by energy companies to customers for load reduction and or shifting

♦ New buildings:

- i. Ensure the design encompasses the energy and financial targets desired by the investor
- ii. Ensure there is a balance between the architects desires to make a "statement" and the functionality of the building. eg A grand foyer vs an efficient HVAC system.
- iii. Do not let the tendering and desire for lower prices take over the agenda

- iv. Increase the time and dollars available to design and document the building from concept through to the end of its economic life are available
- v. Ensure that the council building approval process includes a review of not only the design but also the documentation of the HVAC system from design through to operation and maintenance
- vi. Ensure the tendering process give the benefit of HVAC system changes to the financier.
- vii. Use a “base bid and alternative” tendering process. In this process all tenderers have to tender to a specific specification This sometimes can go to actually specifying the models and brands of equipment to include in the base bid. If the tenderer wishes to offer an alternative then they must specifically nominate the change(s) and the dollar difference in the alternative from the base bid. The financier/owner then can accept the savings or extra cost and get the benefit rather than the cost cuts going to the contractor.

I see little connection to internal comfort conditions and the outside temperature in most buildings. However there are a couple of strategies that could be considered:

- In buildings such as shopping centres where the clientele is transient the setting of the indoor temperature that follows the outside temperature may be acceptable.
- Raise the temperature in the building as it gets closer to the time the occupants are scheduled to leave the building. I know of instances where the central system is shutoff some time before the time the occupants are scheduled to leave the building and only the fans continue to run.

KOZLOV

Relationship to outside conditions

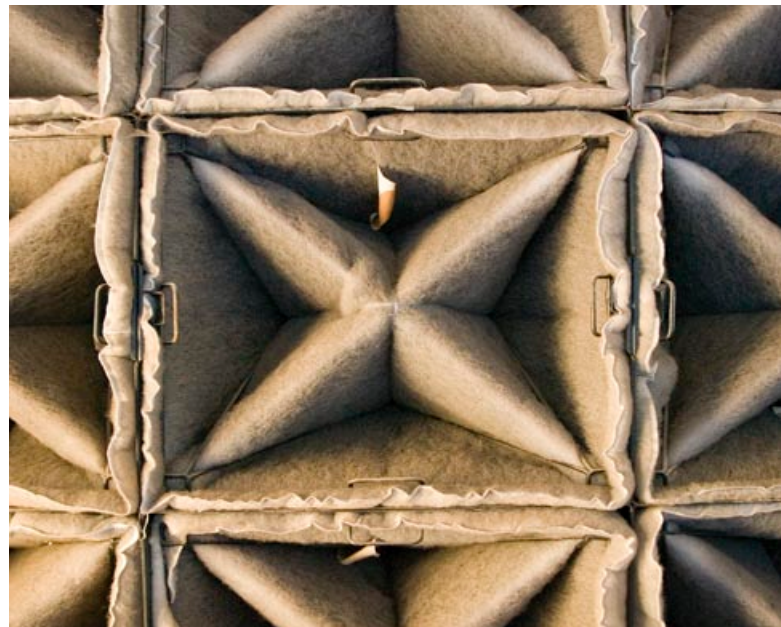
“eg. Temperature setpoints should be floated higher on hotter days too reduce risks of central blackouts.”

PRECIOUS

Benchmarks such as ABGR allow a clear target for performance to be met. This requires close

collaboration between all designers (lighting, façade, HVAC etc) to ensure that energy budgets are allocated and understood. It would appear ideal to have the design engineers involved and responsible for performance through the first 1 -2 years of building performance. Where this is impractical (possibly due to high cost or with the transfer of responsibility to the Design and Construct contractor) very clear documentation defining design intentions is required at each handover stage of the project.

ABGR benchmark has created a target for building managers which has seen a considerable increase in interest in how buildings perform. As more building managers are required to operate buildings to a standard required in lease agreements more interest is created in measuring performance more frequently.



RYAN

The Measurement and Verification Methodology adopted by the Australian Energy Performance Contractors Association will assist..... knowledgeable Energy Auditors. Furthermore the emergence of electrical grid constraint problems at full load will warrant a deeper understanding by consultants of processes that will enable set point raising to shed load, without creating humidity problems and dual coil/path technology is one solution along with thermal storage.

Establishing of benchmarks for all building types is essential because without them other commercial considerations will dominate and override any environmental considerations.

Load shedding can occur through automatic set point adjustments and/or increasing use of thermal storage in phase change materials (eg. Ice).

From a technical standpoint there exists only one significant barrier (to increasing set points) and that is, with conventional air conditioning methods that do not de-couple latent and sensible load control, situations will arise whereby whenever the temperature (or sensible) set point is increased, the space humidity will, under a default response, also rise, because by reducing the amount of space cooling, the resultant driving potential to dehumidify is also reduced.

This increase in space humidity (or moisture content) together with the increased sensible set point (temperature) will generate sick buildings through the propagation of conditions conducive for the growth of moulds, fungi and bacteria. This together with tenants discomfort will severely limit the uptake of this technique in existing or new buildings having conventional air conditioning systems (including chilled beams). This outcome can of course be substantially reduced through air conditioning systems that de-couple sensible and latent load, that enable temperature set point to be raised whilst maintaining indoor humidity at acceptable levels.



TATUM

Some developers are now insisting on involvement by the project team for periods of 2 -3 years after practical completion as part of their scope of works. We suggest that 18 – 24 months would be sufficient, and there is the problem at tender time for the architects, consultants and contractors as to how do you price this? Can you actually determine what the level of involvement would be for the mechanical contractor, particularly if the consultant or architect has produced a poor design?

Improvements to the design, construction and commissioning stages could be improved to ensure that the energy performance of the HVAC system is closer to the design intent can be achieved by:

- Use of an independent auditor or sustainability consultant. We note that in your description of the ABGR in Appendix 2, no mention has been made of the ABGR Commitment Agreement or the ABGR Design Review Panel. You can look up the details but we suggest that this a good program (not because I am a member of the Design Review Panel). Similarly, on a recent large Commonwealth project, there was a requirement for the architect / project team to engage the services of a sustainability consultant who's task was to review and provide comment on the architectural and services consultant design concepts to ensure that all options from design concept right through the formal design, tender documentation, construction, commissioning and post occupancy periods took full advantage of sustainability principles, effectively working for the client and directing the project team, much like the ABGR Commitment Agreement requirements. It would be the independent auditor that would direct the architect / consultants to look at alternatives, to verify the design, verify the computer modelling, the specification the details on the control logic for the operation and control of the plant, etc
- Altering the scope of the project team to include a commitment to and energy performance design and outcome
- Altering the method of tendering whereby each building services consultant issues the tender documents and provided a recommendation to the client to engage that services contractor (who also identifies his subcontractor) and the builder works with the nominated services contractor rather than the builder "wheeling and dealing" for a contractor. This approach was the norm some 10 – 15 years ago.
- Altering the method of tendering whereby the members of the project team are not selected on price

or just because they have a working relationship with an architect, but also on their ability to provide good design, energy simulations, technical ability etc. Make these items a part of the quantifiable criteria to be assessed (as we currently do for mechanical contractors) where say 75% is on price, 10% on projects of a similar nature, 10% on energy performance capabilities of the company, technical expertise, QAQC, etc, etc.

The kind of strategies that are likely to be most effective for improving energy performance of HVAC systems in existing buildings would be:

- Mandate minimum (ABGR) energy star rating for all government leased or owned buildings. This is currently being introduced in Western Australia (and we note that it was not identified in the Appendixes) under the **Government Office Policy**. You can make reference to the policy via the **Department of Housing and Works**, however, even though enforced over 12 months ago, the Department is still in the process of enforcing it.
- The Western Australian **Government Energy Smart Program** is also a positive step whereby interest free funds are provided to government agencies to initiate capital works for energy reduction to meet an energy reduction target, or face penalties. The energy savings are then re-invested. The concern to date with this program has been the “government mentality” scenario of an agency being responsible for the implementation of the program but not providing the necessary assistance to each agency to help identify an energy reduction program, what to tackle first, how to go about it, etc.
- Encourage the uptake of the **Greenhouse Challenge** for private enterprises. This program alleviates the maintenance personnel trying to find funds from the CEO by making the CEO commit fund to reduce greenhouse emissions. We have been concerned that this program, which was showing signs of success has changed its delivery process whereby companies were delegated to actively promote the program, to one whereby a building owner now has to chase the Greenhouse office to join the Challenge.
- Encourage the uptake of the ABGR by private enterprise by making it part of a building owners responsibility to declare the buildings rating when selling or leasing the building so that it becomes the industry norm.

- Encourage the ABGR to be expanded to be used on other types of buildings other than offices, such as hospital, hotels, etc.

Strategies for reducing energy consumption in existing buildings once an energy reduction program was identified would be to concentrate on the following:

- * Subject to the size of the building, if the control system is pneumatic, electric or electronic, then rip it out and provide a DDC control system that can be monitored in real time, that can utilise smart control routines, etc
- * Tune the existing DDC controls – this can generally be done at little or no cost and be carried out as part of the maintenance regime, although we suggest that it would require an independent assessor to review the design intent and operation of the plant before initiating the changes. For instance, some control systems reschedule the air handling unit supply air temperature from 20°C to 14°C. Why? Because the controls guy thought that it was a good range.

However, the coils may have been selected based on a leaving air temperature of 12°C. This means that you have lost 25% of your effective cooling (in simple terms). Why start rescheduling air temperature at 20°C? Etc, etc.

- * Enhance the existing DDC control logic by adding routines which further energy consumption. This may include additional metering and monitoring points.
- * Review the general operation and performance of the plant. Some projects have entailed recommissioning water and air distribution systems.
- * Maintenance. The number of times we have been called to site to investigate why the system is cold or hot, identified that the VAV box actuators don't work or the electric heater banks don't work, have sent the contractor to repair and they inform us that there are no access panels. Never been serviced?

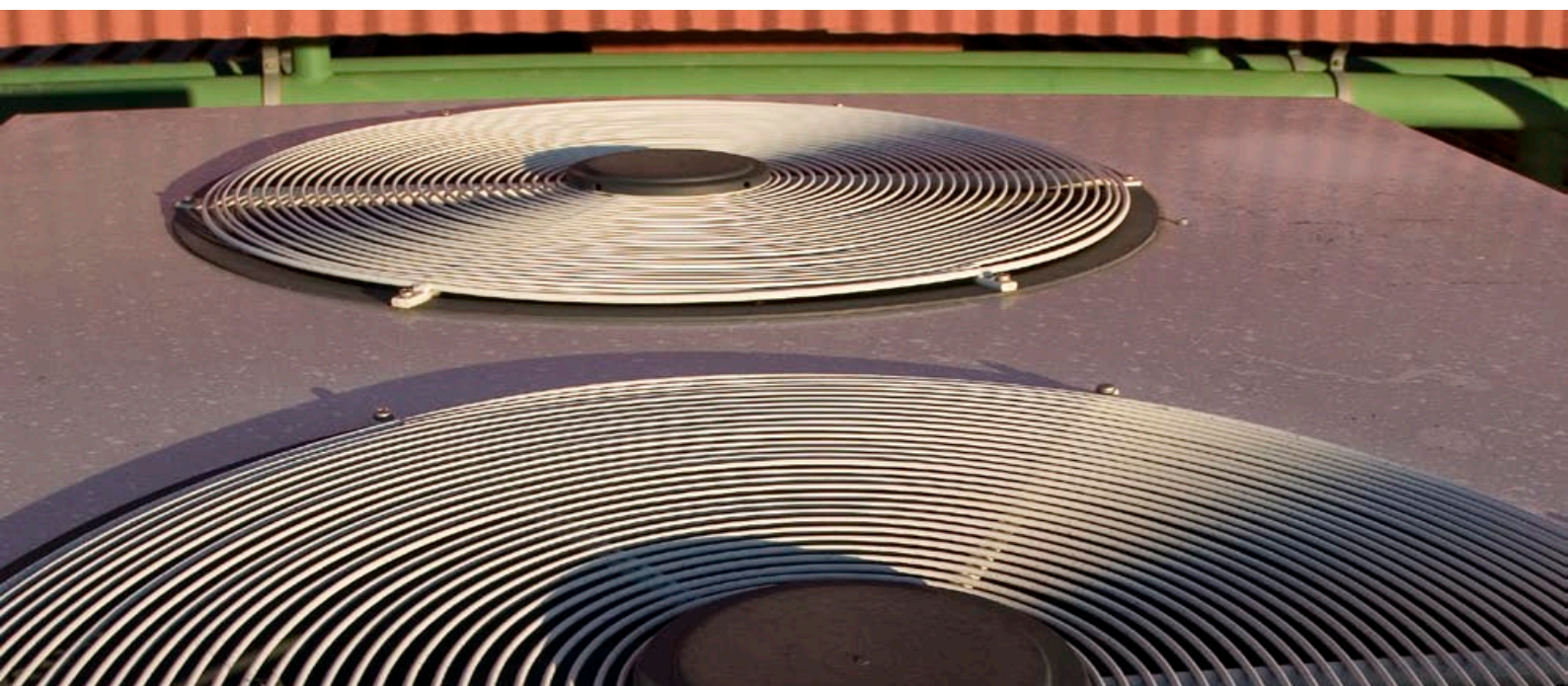
For buildings still on the drawing board, the most effective strategy for improving the energy performance of HVAC would be to:

- * Mandate a minimum energy performance requirement. This is being introduced via the BCA however this is minimum energy performance to eliminate worst practice, not to promote best practice, to lift energy ratings to approximately 3 stars. This should be increased over time.

- * Mandate that all new government buildings achieve a minimum 4.5 star ABGR under the ABGR Commitment Agreement (Refer Western Australian Government Office Policy, which does not quite get to this level.)
- * Encourage that all new private sector buildings achieve a minimum 4.5 star ABGR under the ABGR Commitment Agreement
- * Encourage the ABGR to be expanded to be used on other types of buildings other than offices, such as hospital, hotels, etc.

In relation to the suggestion that internal conditions should respond to external conditions;

If the intent of the question is to allow space temperatures to drop down to 21°C during winter periods and up to 24°C in summer periods, then yes, it would technically possible and socially acceptable (we are doing it on some projects now). However we are making this statement in reference to Perth climatic conditions where humidity is not generally a problem. There needs to be a degree of consideration for tropical locations where humidity may be a problem or where the ambient temperatures are higher than Perth or lower than Perth at low humidity levels where the parameters can be reduced or extended. ASHRAE identify an acceptable comfort zone. It also depends on the ability of your control system and plant to maintain space temperatures at acceptable humidity levels. Typically air conditioning in WA does not have humidity control.



APPENDIX 1

Respondant	Nature of Response	Summary of Response
AIRAH	Comment on earlier draft	
AMCA - Airconditioning and Mechanical Contractors Assoc	Three pages - David Enyon	Focus on Commissioning
Aynsley, Dr Richard - Big Ass Fans	Five pages, many references	Focus on air movement and human comfort, many references to Aynsley publications
Bannister, Paul - Exergy	Adhoc comments on early draft	Has not had time to prepare detailed written response but supported need for strategy
Ballard, Allen - A&R Airconditioning Pty Ltd	Letter	One page on accreditation and commissioning of balancing technicians
Bathish, Hassan - Eco Energy, KL	Detailed report emailed	Detailed step by step response to Sect 7 focused on education - very useful
Bong, Chris - Advantage Air, WA	Three pages via email	Discussion of shortcomings in domestic system design and solutions
Bordass, Bill - Usable Buildings Trust	Report via Adrian Leaman	Making Feedback and Post Occupancy Evaluation Routine
Bordass, Bill and Adrian Leaman	Report via Adrian Leaman	From Feedback to Strategy
Carr, Ray - Discount Air	Meeting notes and email response	Comments on need for heat load calculations in sizing domestic systems
Cullen, Rob - Rob Aire Pty Ltd****	Emails	Reference to his website where he hosts a calculator for domestic systems
Electrical College Board	Detailed response emailed	Step by step response to Sect 7 by Mervyn Green and Alan Sangster
Foster, Syd - Refrig and Aircon Eng, TAFE SA	Request to be interviewed	Not yet conducted
Groppenbacher, Greg - Microguard	Detailed response emailed	Broad response to Sect 7 focusing on perceived major issues
Institute of Engineers Australia	Comments on early draft	
Johnson, Paul C - Aerodynamic Developments	via email	Specific technical question regarding moisture formation in insulating materials
Kozlov, Paul - Power Pax	Comments via Email	Half page - short answers to questions in Sect. 7
Lane, William - Aircontech	Comments via email and report	General comments on skill levels in industry and paper on commissioning process
Leaman, Adrian	Email comments	Links to his website and references
Lee, Trevor - Energy Partners	Hardcopy only	Two pages of notes on computational tools for measuring HVAC performance
Patterson, Mark	Smart Comfort report and comments	Report on issues in domestic and smaller systems circulated recently via Qld Govt and email comments
Precious, Bruce - ECS	Email comments	
Price, Bryon - AG Coombs	PowerPoint Slide	One slide on commissioning information flows - stated total support for strategy
Ryan, Wayne - Air Con Serve Pty Ltd	Report and PowerPoint (not printed)	Detailed and extensive response to parts of Sect 7 plus material on Shaw Method and software products
Sangster, Allan Chair, Electrical Branch Syd. IEAust	One page via email	Specific comments on the use of compliance certificates and accredited certifiers
Tatum, Glen - ACMV Consultants	Report	Detailed response to Sect 7 and broad observations to industry
Thompson, Rhys - AirEng Pty Ltd	via email	single comment - HVAC and efficiency are an oxymoron

APPENDIX 2

HVAC HES KEY QUESTIONS

1. Evidence supports the view that actual energy performance of commercial buildings often falls short of original design intent and that there is a poor correlation between design and eventual energy performance.

Is this your experience and what do you see as the main factors affecting real life energy performance? What are the key barriers or gaps to better outcomes?

2. Consider the initial stages of design, construction, commissioning and handover of a HVAC system in a commercial building. How could the link between these stages be improved so as to ensure the energy performance of the commissioned building is closer to the design intent?

3. In these initial stages, what kind of strategies are likely to be most effective and who is best placed to lead and implement them?

4. Consider the operational management of a building. What skills and knowledge is needed, that in your opinion are most often missing, to ensure that a building performs closer to its actual potential?

5. Conversely, for buildings with poor or average energy efficiency features, what are the key barriers to improving performance in terms of:

- a. Incentive to invest in energy efficiency measures.
- b. Capability to assess and analyse energy performance and implement improved energy management procedures.

6. For existing buildings, what kind of strategies are likely to be most effective and who is best placed to lead and implement them?

7. A number of government measures are about to be introduced (EEOA) or are under consideration (Mandatory Energy ...), which may require the energy and greenhouse performance of commercial buildings to be assessed and publicly reported. Do building owners and managers have the capacity to meet these requirements and to what degree are systems in place (such as measurement devices and data collection) to enable energy monitoring and reporting?



COMMENT INVITED

Comment is invited on any part of this paper by June 30 2006. Responses are particularly welcome that suggest remedies to the obstacles to efficiency identified herein, or that build on or clarify remedies already proposed.

Comments should be directed to Michael McCann, Project Manager, HVAC High Efficiency Strategy at michael.mccann@energystrategies.com.au, ph 02 6260 6444.



