INNOVATIVE HVAC PROGRAM

REPORT

Innovative HVAC Program Report

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Department of Planning

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Executive summary

On the hottest and/or most humid of summer days in Sydney, tens of thousands of commercial air-conditioners simultaneously go into overdrive to keep city workers and residents cool and comfortable. The resultant load on the electricity distribution network places considerable strain on electrical transformers, power lines and associated equipment.

To guarantee and maintain continuous power supplies, electricity distributors TransGrid and EnergyAustralia invest in costly infrastructure which is only required during these peak periods. However, some of this investment could be deferred by the widespread implementation of innovative heating, ventilation and air-conditioning (HVAC) systems that reduce electrical demand on these extreme weather condition days.

The Innovative HVAC Program offered $1 million in funding support for commercial electricity customers to demonstrate innovative HVAC technologies in metropolitan Sydney, and to accurately assess the cost and performance of these technologies and their impact on peak electrical demand.

The Innovative HVAC Program is one of the activities of the Demand Management and Planning Project (DMPP), jointly managed by the New South Wales Department of Planning (formerly Planning NSW), TransGrid and EnergyAustralia. The DMPP was formed to deliver specific conditions of consent as a result of recent augmentation of the electricity distribution network in the CBD area of Sydney. The DMPP's role is to accurately assess, quantify and cost the available demand management resources in the inner metropolitan region of Sydney.

The Program has agreed funding of nearly $650,000 for 11 projects with a total peak load reduction of 1.5 MVA. As at 31 December 2005, only $30,000 was spent and a further $150,000 committed. This is a long way from the 14 applications requesting a total of $5 million in funding to support aggregate peak demand reduction of 22 MVA that were submitted at the expression of interest stage in 2004.

The DMPP team had expected suppliers of innovative HVAC technologies to approach property owners and managers with their technologies and develop innovative HVAC solutions. If these solutions required financial assistance to be commercially viable, then they could jointly approach the DMPP for funding through the Program. When the DMPP team examined the initial tenders, only one applicant met all of the selection criteria. Many of the responses from HVAC equipment suppliers took a more 'sales and marketing' approach rather than creating a solution to the peak demand issue. It was clear that an extensive hands-on facilitation approach would be required. The DMPP invited all proponents to discuss their proposals and to determine a way forward that would meet the selection criteria. The DMPP continued to work with each proponent as a facilitator to extract the relevant information, however this process was very time consuming with the market place struggling to deliver. The first lesson was learned – facilitation is fundamental.

The progress of the Innovative HVAC Program has other important lessons for such programs, as well as suggesting broader implications for demand management in metropolitan Sydney.

Timing is everything. Funding was available over two years but this period did not necessarily coincide with the investment programs of interested participants. Capital works are planned well in advance within tight budget constraints with only priority works accepted. To match these timeframes, funds designed to improve the payback and make innovative programs attractive need to be available and supported for a longer term. They need to coincide with the 'windows of opportunity' opened by capital investment schedules.

The other timing issue relates to the need for measurement and verification to coincide with the summer peak. This means that new equipment needs to be commissioned by the end of a calendar year for its demand reduction to be measured in the subsequent January or February. Projects not ready by February 2006 will not have their peak demand reductions verified until February 2007.

The measurement and verification process is critical to quantifying the peak demand reductions available. It is clear from the Innovative HVAC Program that the measurement and verification process needs to be independent of the proponent. Further, the challenge for such programs is the focus on peak demand reductions as opposed to energy efficiency (which is much easier to measure), and to compare the peak demand reductions to 'what would have been'; not simply 'what was'. If TransGrid and EnergyAustralia are to fund demand management investments, they will need to be confident that there will be sufficient peak electricity demand reductions to defer investments in network infrastructure. Reliable measurement and verification will give them that confidence. Therefore, there is also value in funding the measurement and verification process for those projects that are going ahead without funding.

The financial assessment criteria of the Program sought to include projects that need partial funding to be commercially viable and to exclude projects that would either proceed without funding or not be viable even with funding. The projects in the Program demonstrate how high funding has to be as a percentage of the capital cost for acceptable payback. Although ongoing savings are substantial, resulting in (for some) relatively short payback periods without funding, technologies are not being implemented and proponents argued that they needed funding to go ahead. One reason for this is the perceived risk. A relatively high level of support may be needed to gain internal approval for a new demand reduction technology, whereas property owners and managers and equipment suppliers are more familiar with solutions for energy efficiency.

Although the DMPP team was dedicated to the Innovative HVAC Program and put in a considerable effort supporting proponents through the process, the Program has achieved only limited success in demonstrating the impact of a variety of technologies in HVAC for the reduction of peak demand. This is after all why the DMPP and the Innovative HVAC Program were created – to provide TransGrid and EnergyAustralia with confident estimates of the cost of providing financial support to customers to install demand management equipment (in \$/kVA). These costs could then be compared to the cost of investing in infrastructure to increase the capacity of the electricity distribution network (in \$/kVA).

The market does not seem to be set up for the Innovative HVAC Program's type of approach. To succeed, funds need to be available for a much longer term and accompanied by education and facilitation for each potential customer at a personal level. If the DMPP was to undertake a future program to evaluate innovative HVAC technologies it would develop a methodology which directly targets property owners, assisting them to find solutions suited to their needs and in their timeframes. It would also engage independent HVAC consultants to assess the projects and the outcomes. Such an approach may take longer and cost more than the current Program, but it would assist the market to take advantage of the funding and encourage all to work together to reduce the peak demand using the latest technology.

The innovative HVAC program in context

The Innovative HVAC Program is part of the Demand Management and Planning Project that was created when network service providers TransGrid and EnergyAustralia sought permission to expand the electricity distribution network in metropolitan Sydney.

TransGrid (TG) is the sole electricity transmission network service provider in New South Wales. It is a State Government-owned corporation with assets valued at $3,000 million. Its system of cables, ranging from 132 thousand volts (kV) to 500 kV, serves an area of more than 700,000 square kilometres.

EnergyAustralia (EA) is one of four electricity distribution companies operating in New South Wales. Each distributor has an allocated 'default' area, and EA is responsible for Sydney, the Central Coast and the Hunter Valley. EA connects TG's distribution network to the premises of 1.5 million customers accounting for 5,000 megawatts (MW) of demand.

TG and EA are separate corporate entities. However, their operations are interconnected at key transmission points. They use joint planning standards and undertake joint planning studies to investigate and implement infrastructure investments.

TG and EA received planning permission for the network expansion (called MetroGrid) in early 2002 on certain approval conditions. The capital works components were completed in early 2005.

Objections to the MetroGrid proposal called for the problem of network reliability to be solved by demand management (see Box 1.1) rather than new infrastructure. Although the main concern was the environmental impact of relentless growth in electricity consumption, objectors believed that reducing demand to relieve network constraints would also have environmental benefits.

Box 1.1 Demand Management

Demand management is any action which intentionally reduces the demand on the electrical network when the load is near capacity.

Demand management activities include:

- Customers introducing new energy efficiency measures, impacting demand.
- Arrangements between electricity suppliers and customers that reduce loads on request – either customers paying a lower price for electricity in return for switching off equipment when asked, or direct load control whereby the electricity supplier has the right to switch off equipment.
- Fuel switching, such as replacing electrical appliances with gas-powered units, eg water heaters.
- Distributed generation – installing stand-by generators or solar power.
- Power Factor correction.

Network-driven demand management is concerned with reducing demand on the electricity network in ways that both maintain system reliability in the immediate term and defer the need to expand the network over the longer term. Network-driven demand management, while focusing on relieving network constraints, may also provide some environmental or market benefits. In the same way, environmental-driven and market-driven demand management actions can sometimes provide network benefits.

In its deliberations, Department of Planning (DOP) was not confident that there were sufficient demand management resources available to justify refusing consent to the MetroGrid proposal. In other words, it was too risky to say “no” without good-quality information on demand management options. ‘Good quality’ means knowing:

1# How much demand management is available?

2# How much will it cost?

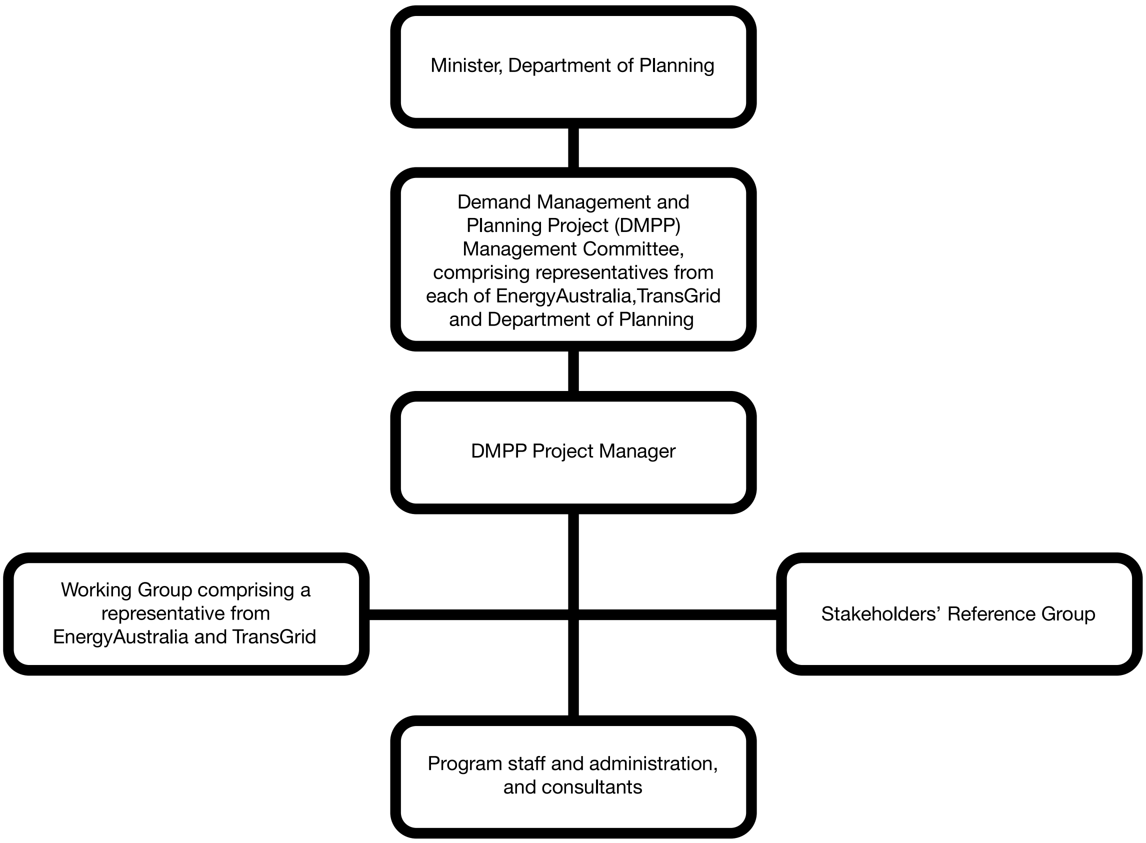
3# Is it available where it is needed?

4# Will it work when it is needed?

Twelve of the conditions of consent required TG and EA to jointly fund a $10 million project over five years from 2003 to 2008. To satisfy these conditions, TG, EA and DOP formed a Management Committee with senior representatives from each organisation, and established the DMPP.

The Management Committee employed a project manager to ensure all deliverables of the conditions of consent are met.

DMPP Structure



The Stakeholders’ Reference Group (SRG) includes representatives from the energy, environmental and property sectors, as well as community groups and government agencies.

Demand Management and Planning Project

The DMPP's task is to accurately assess, quantify and cost the available demand management resources in the inner metropolitan region of Sydney. The DMPP area extends from Hornsby in the north to Sutherland in the south. At its widest point it extends to Ryde in the west. These are the boundaries of EA's 'default' network. This area accounts for 1.1 million EA customers and 4,000 MW of electric power (80% of EA's total capacity).

DMPP Study Area

To meet the conditions of consent for the MetroGrid project, the DMPP must deliver the following outcomes:

- A framework for other organisations wishing to reduce consumers' demand for electricity.
- Identification of the amount and cost of demand reduction opportunities in the inner Sydney region through investigation of Power Factor correction, interruptibility, energy efficiency, cogeneration and energy management in specific areas.
- Confirmation of actual costs and performance of demand reduction projects.
- An inventory of emergency stand-by generators and options for their use for demand management.
- The aggregation, analysis and extrapolation of findings to provide a consolidated view of the demand management resources in the inner Sydney region.
- Reports detailing the methodology and summarising the results of the project for use in Sydney and other areas of New South Wales and for dissemination to the community.

HVAC and the Peak

A major cause of peak summer electrical demand in metropolitan Sydney is the widespread use of conventional HVAC systems in the commercial sector.

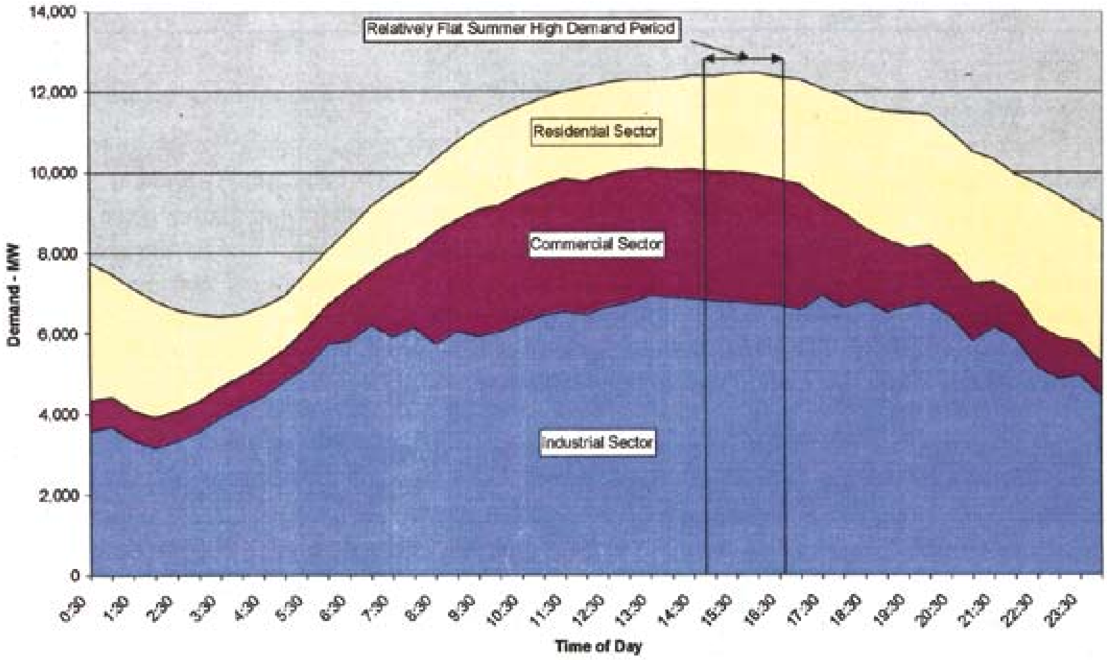
Electricity Demand in New South Wales

In October 2003, the then Ministry of Energy & Utilities published its *NSW Electricity Demand Study – 2003*. The Study was prepared by EMET Consultants Pty Ltd to provide information about the pattern of demand. This information would be the basis for a schedule of electricity restrictions (if ever needed); however, it also provides useful insights into the drivers of the Sydney summer peak load.

The Study analysed the demand for electricity in New South Wales for the 12 months to the end of February 2003. In that period, the summer peak load was 12,456 MW on 30 January 2003 at 4 pm. The growth in peak summer demand between 1995-96 and 2002-03 was approximately 542 MW, equivalent to nearly 5% per year and nearly double the rate of growth in total electricity consumption. The peak crossed over from winter to summer in 2002-03 when the winter peak was 12,156 MW.

The summer load pattern shows a high flat period between 3 pm and 5 pm, with the industrial sector contributing 54%, the commercial sector 26% and residential users 20% of the load (at 4 pm). (Note: the Innovative HVAC Program defines the peak period as "10 am to 5 pm on working weekdays during summer".)

Major Components of the Summer System Demand Curve (NSW, 30 January 2003)



Source: NSW Electricity Demand Study – 2003

Commercial Sector Contribution

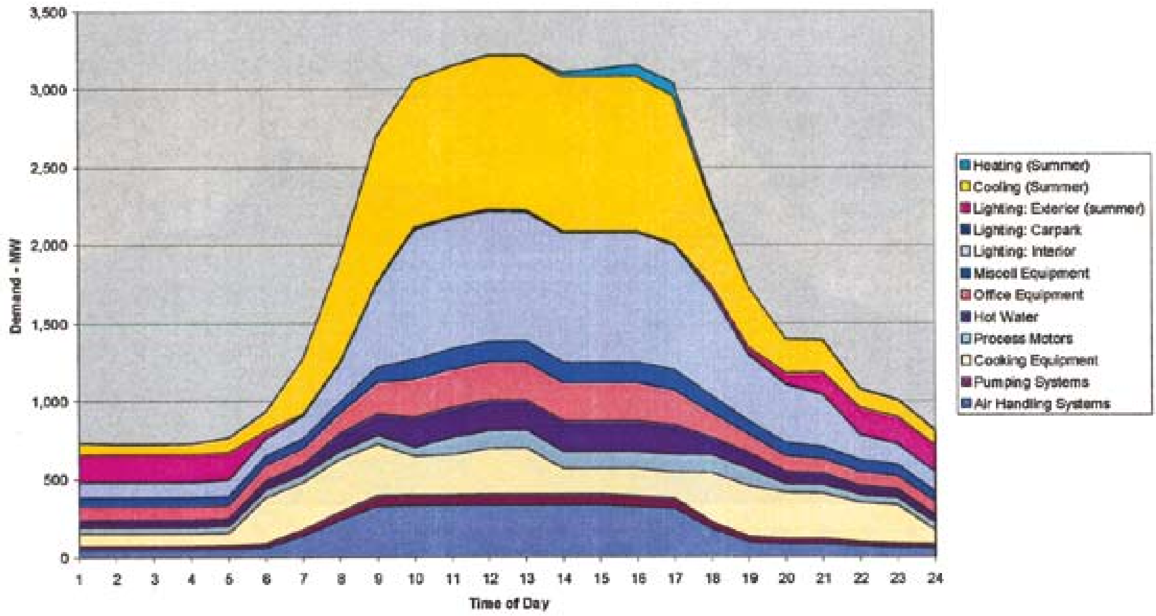
Although the industrial sector dominates the total load, the combined residential and commercial HVAC load is more 'temperature-sensitive', adding about 400 MW from 2 pm to 4 pm. Its contribution increases from 17% to 20% over those two hours.

Installation of reverse cycle air-conditioners ranging in size from 2 kilowatt (kW) to 180 kW capacity in both the residential and commercial sectors is responsible for increasing the electrical load by 1,850 MW in the 10 years from 1990 to 2000. As the commercial sector increasingly adopts the less-efficient reverse-cycle plant in place of traditional central chillers for cooling (and gas-fired boilers for heating in winter), the commercial sector contribution to peak loads will continue to increase.

In larger applications such as office buildings and shopping centres, the cooling demand goes up 2.5% for each degree Celsius (°C) increase in temperature. Extreme summer days, eg 10°C above normal, could add up to 180 MW to the commercial load.

The extent to which the commercial sector drives the summer peak can be seen from that sector's load pattern as estimated in the Study. (See Appendix 1 Conventional HVAC technology for an explanation of how conventional air-conditioning systems affect electricity demand.)

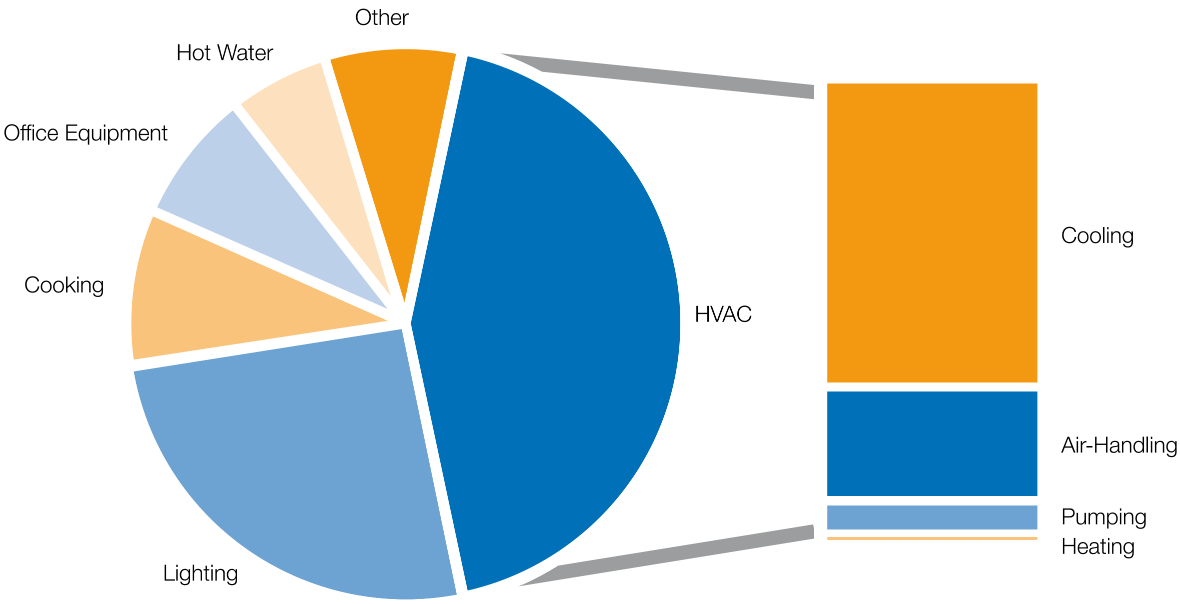
Breakdown of the Commercial Sector Electricity Demand Load for Peak Summer Conditions (NSW, 30 January 2003)



Source: NSW Electricity Demand Study – 2003

The commercial sector comprises over 200,000 establishments involved in construction, trading, transport, communication, finance, property, business services, public administration, defence, community services, recreation, personal and other services. Its contribution to the peak (26%) is higher than its contribution to total consumption (19.3%). On 30 January 2003, the commercial sector's peak load was 3,280 MW, recorded at 1 pm, and HVAC systems accounted for more than 43% of the commercial peak load. Cooling was the largest single load, responsible for more than 30% of the commercial peak load.

Contribution to the Commercial Sector Electricity Demand Load for Peak Summer Conditions (NSW, 30 January 2003, 1 pm)



Source: Data from NSW Electricity Demand Study 2003

Although the data in the Study is for the entire State of New South Wales, the commercial data is heavily biased to Sydney. This is confirmed by the 2000 joint report by TG and EA, *Electricity Supply to Sydney's CBD and Inner Suburbs*. In that report, the 1998-99 summer peak for the inner suburbs and CBD of Sydney was approximately 5,000 MW. Nearly half (2,414 MW) was attributed to the commercial sector. The comparable winter peak was 2,477 MW. However, as the report points out, summer demand is more critical than winter demand. In summer, the capacity of electrical distribution equipment to carry the electric current is lower because of higher ambient temperatures, and the summer peak load persists for more hours of the day. The report attributed the faster growth in the summer peak to the increased adoption of air-conditioners by residential and small-to-medium commercial consumers.

The NSW Study predicted that the summer peak would grow 15% in the five years to 2007-08 with the commercial sector contributing 450 MW of the 1,900 MW added under a 'business-as-usual' scenario. However, the Study expected the commercial sector to exhibit an even faster rate of growth due to the ongoing penetration of less-efficient reverse-cycle air-conditioners.

These results highlight the need to focus on HVAC systems, in particular air-conditioning systems, in the commercial sector. However, they do not explain why building owners and operators were choosing technologies that added to, rather than lessened, the summer peak.

Incentives to Change

The electricity market includes some incentives to reduce peak demand through differential tariffs – peak, shoulder and off-peak. Differential tariffs may encourage some load management but they are clearly not enough to overcome the relatively high capital cost associated with innovative HVAC technologies. This is borne out by the results of a member survey by the Australian Institute of Refrigeration Air-Conditioning and Heating (AIRAH). Although dealing with energy efficiency, the AIRAH survey identified features of the commercial HVAC market that may explain some of the reluctance to adopt demand management strategies.

In May 2003, AIRAH asked its members (air-conditioning, refrigeration, heating and ventilation professionals) if they agreed with 21 statements about barriers to energy-efficient design in the commercial building sector. Six of the statements elicited agreement from 75% or more respondents:

In today's market there is a tendency to adopt the lowest capital cost design solution – not the most energy-efficient solution.	92%
You can have the best designed system in the market but if it is not maintained to a high standard it is not going to operate efficiently.	88%
Developers and financial backers of projects are driving the market and not those involved directly with the design and operation of the buildings.	87%
The current lack of requirements for existing building stock to be energy audited and comply with new BCA (Building Code of Australia) standards is resulting in large-scale energy waste.	80%
Many well-designed and well-installed systems are inefficiently operated as a result of poor commissioning and balancing.	78%
It has been suggested that an industry lack of understanding of the benefit of sound life-cycle costing / cost-benefit analysis prevents energy-efficient options being considered.	75%

Of particular relevance are the first and last statements. The DMPP believes that technologies that deliver lower operating costs over time will not be adopted if they are more costly to purchase and install. This seems to be the case even when the lifetime savings are much higher than the additional capital cost. Both are important cost components in commercial buildings. According to the Air-Conditioning and Mechanical Contractors' Association of Australia (AMCA), services represent a much higher proportion of the capital cost of commercial buildings than industrial premises – up to 30% for hospitals. However, energy is a major ongoing cost in the commercial sector. In a multi-storey office building, energy accounts for 16% of operating costs.

Clearly, property owners and operators would need financial incentives to demonstrate innovative technologies at their premises. Hence, funding was provided through the DMPP for the Innovative HVAC Program. The Program would provide incentives for the installation of innovative HVAC technologies in order to understand the real cost associated with alternative technologies and the reasons for only minimal take-up of these demand reduction technologies in the HVAC industry.

The DMPP allocated $1,000,000 of its $10 million budget to the Innovative HVAC Program to provide financial incentives to demonstrate HVAC technologies that could achieve significant demand reductions in metropolitan Sydney, and to assess the cost and performance of these innovations.

Getting Started

A key starting premise was that the load on the electricity supply system from HVAC applications in commercial buildings drives the summer demand peak in metropolitan Sydney. The other key starting premise was that there are innovative technologies available that can reduce the demand from HVAC applications at the times of the summer peak (ie between 10 am and 5 pm on working weekdays). Further, these technologies are not in general use because they are more costly to purchase and install than conventional equipment, even though they are usually associated with lower operating costs over time. Should the funding required to make the innovative technology commercially viable compare favourably to the cost of adding the electricity distribution capacity it is designed to defer, then a wider implementation of the technology would be justified and the potential for peak demand reductions would be demonstrated.

The DMPP finalised the Project Plan for HVAC Innovations on 9 June 2004. The Plan set out in detail the Program's scope, objectives, deliverables, time frame and cost (see Box 2.1).

Box 2.1 Innovative HVAC Program Objectives and Deliverables

Objectives

- To identify new or innovative technology in HVAC that will substitute existing standard HVAC technology to actively reduce demand at peak times in specific applications.
- To demonstrate authoritatively the costs, technical aspects and performance parameters so as to facilitate the innovative technology in a wider uptake.

Deliverables

- Implemented projects that deliver the forecast demand reduction.
- Development of a business model based on the results of implemented projects that detail the financial, social and environmental implications of the outcomes.
- An understanding of the constraints to use of the implemented technology, and the industry perception and status of the technology.
- Demonstrated consideration of and comparison to other (domestic and international) projects of similar size and nature.

The Innovative HVAC Program comprises five stages:

1# Expression of Interest (EOI) from 14 June 2004 to 6 September 2004

2# Evaluation, ranking and short-list (of EOIs received) from 7 September 2004 to 8 October 2004

3# Request for Proposal (RFP) from 9 October 2004 to 22 November 2004

4# Implementation (funding, installation and commissioning) from December 2004 to December 2006

5# Reporting to be completed by end December 2007.

The intention was for successful tenderers at the EOI stage to be invited to submit detailed applications for funding, and the RFP document submitted to the DMPP Management Committee for approval. The Program set an upper limit on individual projects of $250,000, however individual entities could propose more than one project. Projects could be new equipment or refurbishing existing equipment. In establishing this process, the Project Plan indicated challenges that had to be addressed, including:

1# Timing – many submissions would be dependent on the timetables of capital works programs.

2# Facilitation – it would require a full-time effort to support proponents through the process and facilitate the implementation of the innovative technologies.

The EOI Stage

The EOI document informed prospective project proponents about the DMPP and the Innovative HVAC Program, and invited "expressions of interest for the part funding of projects (in the area of HVAC innovation) which will achieve reductions in peak demand on the electricity network … in the CBD regions of inner metropolitan Sydney".

'Innovative' was defined in the Plan to mean "demonstrating elements that are not commonly used in current practice or which constitute a very small proportion of the market for new and refurbished HVAC equipment". To guide proponents, the EOI identified a set of technologies and systems (see Appendix 2 Innovative HVAC technologies), although the list was not meant to be exhaustive.

Proponents were asked to provide information about their capability; other stakeholders; their project(s); location(s); proposed equipment; existing equipment (or current practice for new installations); timing; benefits, in particular an estimate of the peak demand reduction (in kVA – see Appendix 1 Conventional HVAC technology for an explanation of terms for measuring power); and an indication of the total capital cost and the funding sought.

Proponents were asked for sufficient details to allow their projects to be assessed for participation in the RFP stage under seven criteria (see Box 2.2).

Box 2.2 Innovative HVAC Program Selection Criteria

1 The project will lead to a measurable and consistent reduction in peak demand on the electricity network at times of critical loading (ie between 10 am and 5 pm on working weekdays in summer).

2 The peak demand reduction level achieved for any individual project will be a minimum of 50 kVA.

3 The project would not be economic and would not proceed without funding support.

4 The project is technically feasible and financially viable when considered with funding support.

5 The project includes elements of risk, technical innovation or unknown factors in cost or performance that will benefit from implementation support.

6 The project will be representative of a class or type of project that is repeatable and of a potential scale that is likely to have an impact in terms of deferring the expansion or augmentation of electricity network infrastructure.

7 The project represents potentially good value for money as a more widely adopted demand management project. This will be measured in terms of dollars of support per kVA of demand reduction realised.

The first criterion was critical as it relates to a proposed project's impact on peak demand.

The lower limit of 50 kVA was intended to exclude small residential projects while still capturing all levels of commercial activity from small retail premises to large commercial high-rise buildings. (Note: the demand from a household room air-conditioning unit is no more than five kVA.)

The third, fourth and fifth criteria were used to exclude projects that are commercially viable in the current market as well as research and development projects. The challenge was to fund projects that demonstrate existing technologies that are not being implemented because of their higher capital cost. The risk was that the 'financial viability' criteria could exclude some technologies with considerable potential to reduce peak demand at a reasonable cost. The capital cost could be high mainly because of economies of scale, whereas widespread implementation if the technology was successfully demonstrated could significantly reduce the capital cost.

The aim was not demand reduction per se, but demonstration of technologies that could be widely implemented at a reasonable cost. Recall that TG and EA are prepared to pay for demand reductions that defer investment in infrastructure. The amount they are prepared to pay is determined by the cost of financing the investment. Further, the EOI document added that the funding was not meant to cover the total cost of the project, but ideally between 10% and 20% of the net present value of the total project. The proponents should also achieve a financial return through energy cost savings.

Getting Noticed

With the EOI document ready to go, the challenge was to make sure it reached the 'right' people in time for them to prepare a successful submission. The issue of a suitable response period generated vigorous debate within the Program team. Proponents only needed to prepare an indicative proposal at this stage, so some thought 12 weeks was too long.

In settling on 12 weeks, the DMPP argued that the time for responses needed to be 'longer than usual' due to the innovative nature of the projects; the potential for partnerships; the challenge of identifying sites; and, importantly, time for the Program team to market and promote the Program with potential participants.

An advance notice in May 2004 was circulated at the ARBS (Air-Conditioning, Refrigeration and Building Services) Exhibition in Melbourne by a key member of the SRG, McGregor & Associates, which is a HVAC consulting firm specialising in energy efficiency and demand management. Director Paul McGregor was one of the first to achieve AIRAH (Australian Institute of Refrigeration Air-Conditioning and Heating) accreditation in the field of design and mechanical engineering pertaining to the HVAC and refrigeration industry.

The advance notice generated some early interest from technology and property companies, and was followed by a major effort to contact all potential participants. The Program team identified the target audience as HVAC equipment manufacturers, suppliers and installers, as well as building owners, building managers, building maintenance contractors and local government authorities. The Program team knew that if they could reach the membership of the professional organisations they would maximise the Program's exposure. They made contact with the following organisations:

- Australian Institute of Refrigeration Air-Conditioning and Heating
- Air-Conditioning and Refrigeration Equipment Manufacturers Association of Australia
- Air-Conditioning and Mechanical Contractors' Association of Australia
- Chartered Institute of Building Services Engineers Australia and New Zealand
- Association of Consulting Engineers Australia
- Factory Equipment News
- Property Council of Australia
- Green Building Council of Australia
- Australian Constructors Association
- Facility Management Association of Australia.

Australian Institute of Refrigeration, Air-Conditioning and Heating (AIRAH)	is a specialist membership association for air-conditioning, refrigeration, heating and ventilation professionals. AIRAH represents over 10,000 professionals across Australia, and maintains a register of energy auditors. In operation for over 80 years, AIRAH attributes its longevity to its strong links with like-minded organisations around the world and the successful delivery of key member benefits including representation, dissemination of technical information, networking, member recognition and education and training.
Air-Conditioning and Refrigeration Equipment Manufacturers Association of Australia (AREMA)	is a HVAC industry association representing senior managers and professionals from nearly 40 of Australia's major companies actively engaged in the manufacture and/or marketing of air filtration, air-conditioning and refrigeration equipment. AREMA covers all key industry sectors including: unitary equipment, central plant equipment, cooling towers, evaporative coolers and air filters.
Air-Conditioning and Mechanical Contractors' Association of Australia (AMCA)	is an organisation of nearly 140 air-conditioning and mechanical services companies. Members of AMCA design, install and provide ongoing service for air-conditioning and mechanical ventilation systems, and have worked on the most complex projects in Australia.
Chartered Institute of Building Services Engineers Australia and New Zealand (CIBSE)	is a chapter of an international organisation with 17,000 members in 40 countries. CIBSE represents and provides services to the building services profession – lighting, heating, ventilation, air-conditioning, public health systems and lifts. These services typically account for between 30% and 40% of total construction costs in commercial buildings. The institute covers all aspects of design, installation and maintenance, and is dedicated to the development of better buildings through education, research, communication and maintaining an active role in determining governmental regulations and legislation.
Association of Consulting Engineers Australia (ACEA)	is a business organisation that represents and provides assistance to Australian consulting engineering firms of all sizes as well as sole practitioners nationwide. ACEA member firms constitute over three-quarters of the consulting engineering firms that employ ten or more people. Services that ACEA firms provide include building, infrastructure, transport, communications and IT, project management, environmental management, water engineering, electrical, geotechnical, chemical, energy, acoustical and mining.
Factory Equipment News (FEN)	is a monthly manufacturing industry publication with information on new products, technology updates and industry news for engineers, technical and product management as well as senior managers – the people with the power to make purchasing decisions. FEN's circulation exceeds 15,000.
Property Council of Australia (PCA)	is the leading advocate for the Australian property industry providing advocacy, information, networking, communications and professional development services to large corporate property owners and developers.
Green Building Council of Australia (GBCA)	represents companies, organisations and government departments. GBCA's mission is to define and develop a sustainable property industry in Australia and to drive the adoption of green building practices through market-based solutions.

Australian Constructors Association (ACA)	represents construction contractors that carry out business in two or more Australian states and have an annual turnover in excess of $200 million. ACA member companies include Australia's largest construction companies with a combined annual revenue in excess of $15 billion. They collectively employ over 49,000 people in their Australian and international operations.
Facility Management Association of Australia (FMA Australia)	represents professionals involved in the strategic and operational management of facilities in public and private sector organisations. FMA's more than 1,400 members coordinate the strategic and operational management of facilities in public and private sector organisations. They are the key decision-makers in the areas of communications, utilities, maintenance and other workplace services.

Surprisingly, at first the Program experienced a mixed response. In hindsight, the longer lead time for EOIs to be submitted was a good decision. It took anywhere from three to seven weeks and considerable persistence by the Program team for the organisations to either inform members through their newsletters or to place the information on their websites. That being said, key equipment supplier associations were keen to convey the opportunity to members. For example, within three weeks AMCA had inserted a one-page fact sheet in its printed newsletter and announced the EOI at the July 2004 meeting of its council, which was attended by the major air-conditioning contractors. Within four weeks, CIBSE had posted a notice on its website with a link to the full EOI documentation, and AREMA placed a notice with a short description of the Program and a link to the full EOI documentation in the August news section of its website under the heading, *Opportunities for air-conditioner suppliers and installers*. It also sent an email about the Program to all AREMA members in mid-August 2004.

Not all associations put a hyperlink to the full EOI documentation or the relevant webpage on the DMPP website. That meant interested parties had to contact the DMPP direct to request the EOI documentation. There were at least 50 inquiries as well as the many direct downloads.

The Program team estimates many hundreds of sets of EOI documentation were circulated, and is confident that the offer of funding under the Innovative HVAC Program had reached its target audience.

By the closing date of 6 September 2004 there were 14 registered tenders. However, at $5 million, the total requested funding was more than five times that available. It seemed then that the challenge would be in ranking the projects and deciding which should be progressed through the RFP stage. This decision was complicated by the quality of the EOIs received.

The RFP Stage

Of the 14 EOIs only one was in a format that could be developed easily into a successful proposal – that of a major live entertainment facility (the Venue[1]). The Venue's proposal not only met all the criteria but it clearly explained and quantified the demand reduction and costs. The other proposals had one or more gaps in this information. That being said, they all presented interesting technologies that appeared to have potential. To give all proponents the opportunity to convert their EOIs into successful proposals, the Program team held face-to-face meetings with them to guide them through the process.

By February 2005 the list of proponents had dropped to 10, with 17 projects totalling $1,659,629 in requested funding of which 13 were 'agreed' projects totalling $1,003,050. 'Agreed' projects had the Management Committee's sanction to proceed. This meant they were considered of sufficient potential to warrant the effort required in preparing a full submission and the proponents wished to continue their participation. It also meant that, providing they met the selection criteria as expected, they would be approved for funding. Some projects that would have met the criteria were withdrawn for other reasons (including the Venue's project). The withdrawn projects, as well as those that did not meet the criteria, are discussed in Chapter 4 Lessons from the innovative HVAC program. By 31 October 2005 there were 11 projects from seven proponents and $644,378 in agreed funding. These are described in Chapter 3 The innovative HVAC projects.

[1] 'The Venue' not identified at the request of the proponent.

The innovative HVAC projects

The seven successful proponents are mostly HVAC equipment manufacturers, suppliers and installers with ownership or knowledge of innovative technologies and access to potential clients with premises suitable for demonstrating these technologies.

1# Synergy Thermal Technologies

2# Discount Air Conditioning

3# University of Technology Sydney

4# HyChill Australia

5# Muller Industries

6# Munters

7# Phase6

Of the nearly $650,000 agreed funding for projects (see Table 3.1), just over $30,000 was spent and only $150,000 committed as at 31 December 2005.

The varied progress of the projects through the Program highlights some of the challenges associated with demonstrating and implementing innovative technologies. These challenges are discussed in more detail in Chapter 4 Lessons from the innovative HVAC program. The technologies are explained in Appendix 2 Innovative HVAC technologies.

Table 3.1 Innovative HVAC Projects as at 31 December 2005

Proponent	Technology	Approved Projects as at 31/12/2005	Total Cost ($) (excl. GST)	Funding Sought ($) (excl. GST)	Estimated kVA Reduction	Proposed Funding / kVA
Synergy Thermal Technologies Pty Ltd	Ice thermal storage (IceTower®)	Littles Pharmacy, Ashfield – Work in Progress	$10,910	$7,601	19	$400
		Drummoyne RSL – Work in Progress	$34,115	$31,289	40	$782
		Barron & Rawson, Revesby	$19,109	$13,109	25	$524
		Byers Meats, Regents Park	$363,284	$72,727	300	$242
University of Technology Sydney	Dual Indirect Cycle Energy Recovery (DICER)	Rooms 7.01 and 7.06, UTS Tower Building, Sydney CBD – Work in Progress	$115,000	$87,000	76	$1,145
Discount Air Conditioning Pty Ltd	GHP Gas Engine Cliimate Control System	Grand United Building, Sydney CBD	$2,365,000	$250,000	618	$405
HyChill Australia Pty Ltd	Hydrocarbon Refrigerant	Macnaught Pty Ltd, Turella	$25,616	$12,800	10	$1,280
Muller Industries Australia	Dricon heat rejection unit	Alcatel, Alexandria	n/a	$5,000	20	$250
Phase6 Pty Ltd	Airconomist and Phase6 Control	Electroboard Head Office, St Leonards	$23,500	$12,000	60	$200
	Shaw Method with Rippleband DLC and Phase6 Controls	AGC House, Sydney CBD	$165,000	$75,000	200	$375
Munters Pty Limited	Humidity Control Unit HCU6000	Supermarket	$135,000	$77,852	62	$1,256

3.1 Synergy

Proponent	Synergy Thermal Technologies Pty Ltd
Projects	Littles Pharmacy, Ashfield
	Drummoyne RSL, Drummoyne
	Barron & Rawson, Revesby
	Byers Meats, Regents Park
Technology	IceTower®

Summary

Synergy Thermal Technologies submitted five proposals to install ice thermal storage technology in a range of premises – four commercial and one residential. The residential proposal did not proceed past the EOI stage as the domestic sector is not the focus of the Program.

Synergy holds the Australian licence for IceTower®, a proprietary ice thermal storage system that reduces peak demand by shifting the cooling load from peak periods to off-peak periods. Synergy proposed a range of applications to demonstrate the technology across different types of businesses – retail, entertainment, commercial and industrial.

Littles Pharmacy, Ashfield

Littles Pharmacy	in Ashfield is a suburban commercial pharmacy business owned and operated by Patrick Van and Mary Co. The owners were planning to replace an old and ineffective packaged air-conditioner with a reverse-cycle split unit, and had planned to do this before the pre-Christmas sales rush in 2004. Synergy proposed the alternative technology, an IceTower®. Although the IceTower® is cheaper over the life of the equipment, its capital cost is higher. The owners were not prepared to risk the four-times higher purchase price of $20,001 for uncertain, if substantial, electricity cost savings. The Innovative HVAC Program funding of $7,601 lowered the risk sufficiently for the owners to agree to the installation of the IceTower®. The peak demand reduction was estimated at 19 kVA and the cost of supporting this technology in this application is estimated at $400/kVA. The Littles Pharmacy project is the most advanced in the Innovative HVAC Program. Funding was approved urgently in December 2004 and the equipment installed in time for the pre-Christmas sales rush. The HVAC load was measured in November 2004 and again in January 2005, and funding totalling $6,909 was paid in two instalments. However, the reporting process revealed an issue with verification of the peak load reductions (see Chapter 4 Lessons from the innovative HVAC program).
Drummoyne RSL	is a three-storey building located on Victoria Road. It has two bars, two kitchens with a cool room, a keg room and numerous fridges. The building has significant air-conditioning and refrigeration requirements during the day and evening in summer, and was serviced by four thermal storage units installed in 1996. These units had not performed to expectations and the owner of the building planned to replace the units with traditional refrigeration technology. The Innovative HVAC Program agreed to fund more than 90% of the capital cost to facilitate demonstration of a technology with widespread application and large peak demand reduction. The estimated peak load reduction is 40 kVA when compared with the alternative system that would have been installed if there was no funding. The peak load reduction is 20 kVA when compared to the existing thermal storage system. The cost of supporting the estimated peak demand reduction of 40 kVA is $782/kVA.
Barron & Rawson	is a plastics manufacturing plant in Revesby. The rooftop packaged air-conditioning unit that supplies conditioned air to the office building is over 15 years old and no longer performs the air-conditioning task required. In particular, it does not maintain a comfortable air temperature on very hot days. Like the unit in Littles Pharmacy, it was due to be replaced. Synergy proposed replacing the unit with two IceTowers® at a total cost of around $19,109, 70% funded by the Innovative HVAC Program.
Byers Meats	a private meat processing company, is building a new factory in Regents Park. The entire factory is to be refrigerated and the factory office is to be air-conditioned. The economic viability of the factory is determined by the cost of refrigeration which is the single largest business cost. The initial construction plan included a conventional DX refrigeration system. Although the details of this project are not finalised, the anticipated reduction in peak load is significant at 300 kVA and the cost of supporting the project is at the lower end for all projects at $242/kVA.

Status as at 31 December 2005

All four commercial projects were approved for funding by the Management Committee and are at various stages of implementation.

The Littles Pharmacy project is installed and funded. Issues relating to measurement and verification were being addressed, with an independent electrical engineer verifying the HVAC peak load reduction.

The Drummoyne RSL project installation was completed in the last week of October 2005 and $13,767 in funding was paid. The project was being commissioned and tested as at the end of 2005.

Synergy was developing optimising technology before commencing the Barron & Rawson project, and the new Byers Meats' factory is now due for construction in 2006.

3.2 Discount Air

Proponent	Discount Air Conditioning Pty Ltd
Project	Grand United Building, Castleraegh Street, Sydney CBD
Technology	Advanced GHP, a gas-engine driven multi-indoor unit climate control system

Summary

The owner of the property, Celleb Pty Ltd, is refurbishing the building and adding a number of floors. Discount Air Conditioning Pty Ltd is installing the new HVAC equipment. The original plan was to install an electrical system. When Discount Air found out about the Innovative HVAC Program, it presented the idea of a gas-powered system to Celleb.

Discount Air – with the manufacturer of the Advanced GHP, Mitsubishi Heavy Industries Pty Ltd – has been installing gas-powered air-conditioning systems for three years in Australia. These systems are common in Japan, but so far have only been used in Australia in locations where there are electricity supply constraints. Grand United Building falls into this category.

The electrical system has a lower capital cost ($1.5 million) but would have required a major upgrade in the electrical supply to the building. The gas-powered system has a higher capital cost ($2.36 million), but does not require the upgrade and will be cheaper to run. However, without funding support, Discount Air argues it is still less expensive to upgrade the electrical supply and install an electrical air-conditioning system than install a gas-fired system.

The funding of $250,000 is only 11% of the total cost but represents nearly 30% of the additional cost (without taking the need to upgrade the electrical supply into consideration). Using the initial estimate of peak demand reduction of 618 kVA, the cost of supporting this innovative technology is $405 per kVA.

From the point of view of the DMPP, this project guarantees a reduction in peak electrical demand and is an excellent example to other developers considering similar building refurbishments in Sydney's CBD. This technology has significant potential for widespread implementation in the study area.

Mitsubishi Advanced GHP unit

Status as at 31 December 2005

The Management Committee has agreed in principle to the allocation of $250,000 under the Program to support the installation of the climate control system. The capital works for the refurbishment are scheduled for 2006. The Development Approval was being finalised as at the end of 2005. When it is approved and the construction drawings are finalised, the DMPP will appoint a HVAC consultant to estimate the peak demand reduction. Once the timetable is finalised, the RFP will be completed and submitted for approval.

3.3 UTS

Proponent University of Technology Sydney

Project Plant Rooms 7.01 and 7.06, UTS Faculty of Engineering's Tower Building, Sydney CBD

Technology Dual Indirect Energy Cycle Recovery (DICER)

Summary

University of Technology Sydney (UTS) is a city-based university. Its building management team has shown a keen interest in energy efficiency and demand management. In its EOI, UTS submitted five proposals: the installation of window glazing, rotary enthalpy wheels and variable speed controls for fans and motors in its 30-storey Tower Building; and the installation of a DICER system at two of its research laboratories. Even though the DICER system is closer to a demonstration project than a proven technology, the DMPP chose to proceed with the technology in two of the plant rooms in the Tower Building.

UTS will install a DICER unit in each of the plant rooms plus a variable speed drive motor to a fan in room 7.01. The DICER system combines a heat exchanger with an integrated cooling coil and an indirect evaporative cooler. It will be used to make the outside air cooler and drier before it is passed over the existing cooling coils.

The capital cost of installation is $115,000, of which the Innovative HVAC Program is funding $87,000. With an estimated reduction in the peak electrical load of 76 kVA (including 5 kVA due to the addition of variable speed drives in room 7.01), the cost of supporting this technology is $1,145 per kVA.

The benefit to UTS is in reduced electricity costs. The payback without funding is more than 10 years; with funding, around three years. Two plant rooms represent only a small proportion of the air-conditioning task in the 30-storey building. This will make measurement and verification a challenge.

DICER units do not replace existing equipment; rather they are add-ons to conventional systems designed to reduce energy consumption and electricity demand. The technology has the potential for significant peak load reductions if it is applied on a large commercial scale across metropolitan Sydney, and the plant rooms in the Tower Building are suitable locations for demonstration.

FICOM DICER

Status as at 31 December 2005

The Management Committee approved funding of $87,000 in August 2005. It is anticipated that funding from UTS is imminent but the summer of 2005-06 has been missed. The project works will be installed and commissioned in 2006 with measurement and verification in the summer of 2006-07.

3.4 HyChill

Proponent HyChill Australia Pty Ltd

Project Macnaught Pty Ltd, Henderson Road, Turella

Technology Refrigerant Replacement

Summary

HyChill Australia Pty Ltd has been promoting the use of hydrocarbon refrigerants in Australia since the early 1990s, and saw the Innovative HVAC Program as an opportunity to demonstrate its products. HyChill initially identified Macnaught's administration offices as a suitable demonstration location.

HyChill proposed to replace the hydrochlorofluorocarbon refrigerant R22 in two packaged air-conditioning and heat pump systems with the hydrocarbon refrigerant HR290. It expected the changeover to reduce peak electrical demand by 10% on a hot summer day.

In this small commercial application, this represents 10 kVA. The cost of the replacing the refrigerant is $25,616. Funding of $12,800 is 50% of the total cost, and implies a cost of support for the innovation of $1,280 per kVA, making it one of the more 'expensive' options in the Program. However, the DMPP supported this project because of its potential to be applied across the study area. Many small reductions could result in a very large saving for the Sydney metropolitan area.

HyChill refrigerant

Status as at 31 December 2005

The Management Committee approved the funding on 5 April 2005. The project was to be implemented in either January or February 2006 to coincide with the summer peak. During inspection of the premises for the purpose of measurement and verification it was decided that, due to problems with access to the existing system, another location would be more appropriate for the demonstration. Two potential locations were identified in December 2005 and were to be inspected in January 2006.

3.5 Muller Industries

Proponent	Muller Industries Australia
Project	Alcatel, Botany Road, Alexandria
Technology	Dricon heat rejection unit

Summary

Muller Industries Australia supplies industrial and commercial air-conditioning and refrigeration systems and has developed its own pre-cooling unit, the Dricon, designed as an inexpensive retrofit.

Muller Industries submitted two projects to the Innovative HVAC Program: the installation of an evaporative pre-cooler pad kit to an existing Carrier air-cooled packaged air-conditioning unit at the Mosman Art Gallery; and the installation of three Dricon units in place of conventional air-cooled condensers at Alcatel's head office building in Alexandria. ING owns the building and was considering installing air-cooled condensers to replace the existing water-cooled condensers.

The Mosman Art Gallery project was not approved for funding because it was estimated to reduce peak demand by only 5 kVA. Although other funded projects did not meet the criterion for a minimum peak reduction of 50 kVA, they all involved reductions of at least 10 kVA. Under 10 kVA it would be difficult to ascertain how much peak demand was attributable to the new equipment. The 'minimum kVA' criterion is discussed further in Chapter 4 Lessons from the innovative HVAC program.

However, the payback period without support was less than one year, so the project went ahead without funding. As early as the EOI stage, Muller Industries advised the DMPP that ING would go ahead with the installation of the Dricon systems without funding. Funding was still considered by the Innovative HVAC Program team to take advantage of the results of the project. Although there were Dricon units installed in Queensland and Victoria, at the time there were none operating in New South Wales.

Status as at 31 December 2005

To access the information from the project, the Innovative HVAC Program allocated $5,000 for measurement and verification. The consulting engineer on the project has submitted a proposal for a 12-month verification program at a cost of $14,800. Muller Industries costs for associated work will be $1,500. In the original submission, the proposed program of measurement and verification was costed at $6,000 for measurement and verification analysis and reporting, in addition to $11,000 for monitoring the system over two consecutive summers. This level of monitoring is not necessary to measure the peak load reductions. The Program team has requested that the electrical load profile of the equipment be measured on one hot day (35°C or higher) with the pre-cooler isolated periodically throughout that day. The DMPP also offered to fund the purchase of 12 months of historical data and 12 months of ongoing measurement of the electrical load at the Alcatel site by Testing Certification Australia (TCA), estimated to cost $400. Additional works were being undertaken and some optimisation was still underway.

3.6 Munters

Proponent Munters Pty Limited

Project Humidity control unit in a supermarket

Technology HCU6000

Summary

Munters Pty Limited is a global supplier of humidity control equipment and is represented in 25 countries. In Australia, Munters has a manufacturing plant and offices in Albury, New South Wales.

Munters initially proposed two projects: installation of an Econovent in each of the eight air-handling units in a new 20-storey commercial building in North Sydney, and installation of an HCU6000 humidity control unit at a supermarket with plans to refurbish.

Unfortunately, the Econovent project was not approved for funding because the owner of the commercial building did not provide the required financial payback information despite many requests.

Munters approached two major supermarket chains with a proposal to install a humidity control unit in one of their stores. The first indicated that it was very interested in a demonstration of the technology and agreed to install an HCU6000 when it refurbishes its selected store. However, there was much indecision surrounding the location of the store, resulting in project delays. Similarly, the project at the second supermarket chain is on hold and is not likely to proceed in the near future because that store is not yet due for refurbishment.

Based on data provided by the supermarket, the payback without funding is nearly five years and the proposed funding reduces this to two years. According to Munters, this meets the chain's investment criterion. If support funding is not available, the store would install a conventional HVAC system.

Munters estimate the reduction in peak load from including an HCU6000 in the HVAC installation at the selected supermarket at 62 kVA, which is equivalent to a reduction of more than 40% of the HVAC load of a conventional system.

With such a significant reduction and the opportunity to apply the technology across a number of similar premises in metropolitan Sydney, the DMPP is keen to proceed with a demonstration of the HCU6000 in a supermarket refurbishment.

Status as at 31 December 2005

Two RFPs were in progress, one for each of the supermarket chains. The Management Committee will approve a proposal to install an HCU6000 in a supermarket HVAC system, assuming that the parameters of the proposal are similar to those presented in the EOI. The Program was waiting for supermarket chain management to finalise site selection and give the go-ahead to Munters to proceed.

3.7 Phase6

Proponent	Phase6 Pty Ltd
Projects	Electroboard Head Office, Atchison Street, St Leonards
	AGC House, Carrington Street, Sydney CBD
Technologies	Airconomist
	Phase6 Control System
	Shaw Method
	Rippleband DLC Control System

Summary

Phase6 Pty Ltd submitted four proposals incorporating more than 20 projects in its EOI. Most of the projects involved the installation of Airconomist water spray units and Phase6 controls in a range of commercial properties in Sydney, including offices, supermarkets and hospitals. In keeping with the Program's objective of demonstrating a range of projects rather than achieving outright demand reductions, this proposal was consolidated to focus on three technologies in three locations.

Airconomist is an evaporative cooling system that sprays water over a mesh frame placed in front of the cooling coil.

Phase6 is a 'price and load signal' technology designed to respond to peak abatement requests from electricity distribution companies (eg TransGrid and EnergyAustralia). Although the distribution companies are not yet initiating such requests, Phase6 has the potential to reduce peak demand through commercial power consumers offering, either automatically or on request, to turn off some HVAC components for a limited period during the peak period. The potential peak load reduction is high (20% to 40%) but only for a short period of time (one to two hours).

Phase6 HVAC controls are therefore designed to reduce summer demand peaks, but are not in current practice. Both Airconomist and Phase6 can be linked to Phase6's Rippleband DLC environmental control system.

The combination of two types of technology (a pre-conditioning unit and a control system), and the large number of applications, made the proposals difficult to assess. The Innovative HVAC Program team worked with Phase6 to limit the funding of the technologies to two locations – Electroboard's head office and AGC House. The Shaw Method technology proposed for AGC House also combines pre-cooling with advance controls. It links to Phase6 and uses Rippleband DLC controls.

Indicative peak load reductions are 60–85 kVA at Electroboard's head office and 200 kVA at AGC House, at a relatively low funding cost of $200/kVA for the Airconomist project and $375/kVA for the Shaw Method project.

Therefore, the DMPP wishes to provide the opportunity for these projects to prove their demand reduction potential.

Status as at 31 December 2005

The RFPs were still being prepared. The details of the Electroboard project have been finalised and the DMPP was waiting on the owner of the building to give the go-ahead. The AGC House project was less well advanced.

Lessons from the innovative HVAC program

The progress of the Innovative HVAC Program so far (about half-way through its tenure) already has important lessons for the Innovative HVAC Program and other similar programs, as well as suggesting broader implications for demand management in metropolitan Sydney.

Tricky Timing!

At first pass, the attrition rate from 14 proponents with total funding of $5 million in September 2004 to 7 proponents and funding of just under $650,000 a year later is disconcerting. However, this reflects a major issue for the Innovative HVAC Program – timing. Funds were made available for projects but, if the timing did not fit into the owners' schedules, it was difficult to incorporate. Property owners and facility managers plan their capital works programs at least 12 months ahead, normally within very tight budgets. An innovative solution to replace an already designed concept that is more common and proven to the industry introduces new risks and can upset approved capital programs and assigned budgets.

For example, two major projects that were proposed under the Innovative HVAC Program and were to be funded to the maximum level of $250,000 each were withdrawn only because they would be commissioned after the closing date of the Program. Both projects – the Venue's new control system and Investa's cogeneration and absorption chiller – were innovative, cost effective and well presented. The DMPP team was disappointed that the project construction timelines fell outside the Program's tenure.

A couple of projects (representing less than $100,000 in funding) were withdrawn by the proponents when they could not secure suitable premises in time to demonstrate the technology.

Timing is also affecting successful projects. For example, Munters' proposal to install its humidity control unit in a supermarket is currently stalled waiting for a supermarket refurbishment to commence.

The other timing issue relates to the need for measurement and verification to coincide with the summer peak. This means that new equipment needs to be commissioned by the end of a calendar year for its demand reduction to be measured in the subsequent January or February. Projects not ready by February 2006 will not have their peak demand reductions verified until February 2007.

The market does not seem to be set up for this Program's type of approach. To succeed, funds need to be available for a much longer term and accompanied by education and facilitation for each potential customer at a personal level. This would assist the market to take advantage of the funding and encourage all to work together to reduce the peak demand using the latest technology.

Facilitation Fundamental!

Initially the market favourably responded to the funding offer with 14 applications requesting a total of $5 million to support aggregate peak demand reduction of 22 MVA. Closer examination of the applications revealed that only one applicant met all of the selection criteria. The submissions simply failed to provide sufficient information to show that, on extreme weather condition days, proposed peak demand reductions would occur. When evaluating the submissions at the EOI stage it became clear that if the DMPP wanted to maximise the number of successful projects then an extensive hands-on facilitation approach would be required at every step of the way.

The expectation had been for suppliers of innovative HVAC technologies to approach property owners and managers with their technologies and together develop an innovative HVAC solution. If these solutions required financial assistance to be commercially viable, then financial assistance could be sought from the Program. However, where the proponents were in fact the owners of the property where the technology was to be installed, the proposals were easier to facilitate since the property owner was taking an active role in the process. Many of the responses from HVAC equipment suppliers took a more 'sales and marketing' approach rather than creating a solution to the peak demand issue.

However, the DMPP invited all proponents to discuss their proposals and to determine a way forward that would meet the selection criteria at the RFP stage. The DMPP wanted as many of the proposals as possible to succeed, and undertook an extensive facilitation program to help all the initial proponents whenever possible. The process was very time consuming with the market place struggling to deliver. Some proponents were unable to provide the evidence needed to meet the selection criteria and they elected to leave the Program.

By February 2005, after extensive facilitation, 10 proponents with 13 projects remained viable. Total agreed funding was $1 million and total peak demand reduction was nearly 2.5 MVA. After further facilitation with the proponents, 11 projects with a total demand reduction of 1.5 MVA met the selection criteria, and in October 2005 the DMPP Management Committee agreed funding of nearly $650,000. As at 31 December 2005, just over $30,000 had been spent and only $150,000 was committed. Facilitation is still underway for the remaining projects though it is apparent that the market is unlikely to deliver the requirements of the selection criteria.

Mandatory Measurement and Vital Verification!

The Synergy proposal was one of the few that did not require much by way of facilitation and its projects are the most advanced of the Program. The first project to be approved was the installation of an IceTower® at Littles Pharmacy. This small project was fast-tracked to fit with the owner's time constraint.

Initially the project involved Synergy undertaking the measurement and verification task. The 'before' data met engineering expectations at the time but it transpired that it was slightly overestimated. Then, the 'after' data inexplicably fell short of the predicted reduction in kVA. To gain a better understanding of the situation, the DMPP hired a third-party consultant to investigate. The consultant worked with Synergy and concluded that the 'after' electrical load should be lower than measured in the initial measurement and verification process. The system changed from single-phase to three-phase with the installation of the IceTower®, and the wrong equipment was used to measure the loads. This did not 'faze' the Program team. The consultant will measure the 'after' data and another consulting engineer will estimate the load of the alternative technology that the IceTower® replaced. The difference will be a reliable measure of the peak load reduction in this case.

More importantly, Littles Pharmacy was a cheap (less than $7,000 in actual funding) but valuable lesson which is being applied to the rest of the Program. The consultant is now working with Synergy to develop a measurement and verification process for the other three IceTower® projects. The main issue is where and how to set up the meters. As a back-up for the Drummoyne RSL project, Testing and Certification Australia (TCA) – a subsidiary of EA – will report on the use of power by the entire site. Drummoyne RSL has time-of-use metering that measures power use every 15 minutes and TCA can prepare a report for the 12 months preceding and the 12 months after commissioning. For the Byers Meats project, the Program will spend approximately $15,000 for a consulting engineer to compare the project outcome to the alternative traditional system. The extra costs will be met by the Program budget. Providing financial support for the measurement and verification process is an effective use of the Innovative HVAC Program's funds.

It is clear that the measurement and verification process needs to be independent of the proponent. This lesson will be applied to the other successful projects in the Program. In some cases, measurement is complicated by the nature of the technology. HyChill's refrigerant replacement generates only small changes (~10 kVA) and will need to be accurately measured. Similarly the DICER installation at UTS affects only a part of the system. Although there will be a substantial absolute reduction (~76 kVA), it is only a small proportion (~5%) of the total load of the Tower Building.

The challenge for the Innovative HVAC Program is the focus on peak demand reductions as opposed to energy efficiency (which is much easier to measure), and to compare the peak demand reductions to 'what would have been'; not simply 'what was'.

If TG and EA are to fund demand management investments, they will need to be confident that there will be sufficient peak electricity demand reductions to defer investments in network infrastructure. Reliable measurement and verification will give them that confidence. Therefore, there is value in also funding the measurement and verification process for those projects that are going ahead without funding, such as the Muller Industries' project at the Alcatel building.

Equivocal Economics!

Although the Program team found they had to relax some of the selection criteria (eg the minimum peak load reduction was lowered from 50 kVA to 10 kVA), they were not prepared to just give money away. It was important that the proposals could substantiate the commercial viability of the projects.

Munters' proposal to install its Econovent units at a 20-storey commercial building in North Sydney was not progressed because the building owner did not provide the commercial payback criteria needed to assess the economics of the project, despite several requests.

Innovative HVAC systems and solutions that lower peak demand tend to be much more expensive up-front, with savings in ongoing energy costs over time. For example, in a new construction such as Byers Meats the capital cost of the IceTower® system is nearly $400,000 compared to just over $250,000 for a conventional system (ie 60% higher). The annual electricity cost with the IceTower® system at full load is $14,150 compared to $67,000 with a conventional system (ie 80% lower). In a retrofit situation such as UTS's plant rooms, the capital cost of the DICER system is $115,000 with annual electricity savings of $11,509.

As noted in Chapter 2 The innovative HVAC program, the higher capital cost of new technologies may be due to the economies of scale in production. Where this is the case, the capital cost will fall when the innovations are more widely adopted. In the meantime, 'demonstration' is the objective of the Innovative HVAC Program. The financial assessment criteria set out in the EOI document sought to put economic boundaries around the Program's projects – to include projects that need partial funding to be commercially viable and to exclude projects that would either proceed without funding or not be viable even with funding.

The latter is important because, even if the $/kVA reduction is acceptable to TG and EA, the technology will not be widely adopted if the return for the electricity consumer is not acceptable. For example, the estimated cost of supporting the installation of passive chilled beams at the University of Sydney (at under $1,000/kVA) is well within the range for reductions in projects in the Program. However, maximum funding support of $250,000 would reduce the simple payback period from 38 years to 15.5 years. With or without funding, this project was not considered a financially viable proposition for other potential commercial clients in the study area. The proposal was rejected even though the innovative technology has the potential to reduce peak demand.

On the other hand, the Investa project will not go ahead without funding. The additional cost of a gas-powered generator and absorption chiller ($392,000) would result in a return on investment (ROI) of only 5.5% which is below Investa's requirement. With funding of $200,000 (51% of the incremental capital cost), the ROI increases to an acceptable 11.2%.

In some cases it was not clear whether a project would proceed without funding. Then, the quality of the project was taken into consideration. For example, the gas-powered system being installed at Grand United Building in the CBD has a much higher capital cost ($2.36 million) than the conventional electrical system originally being considered ($1.5 million). However, funding of $250,000 represents 11% of the total cost and nearly 30% of the additional cost. This does not take into consideration the need to upgrade the electrical supply for a conventional system. Gas-powered systems are ideal for applications with such electricity supply constraints. The installation of a gas-powered air-conditioning system in an inner city multi-storey building is an excellent demonstration project, and was approved for funding accordingly.

Muller Industries went ahead with the installation of its Dricon unit at Alcatel's office building without funding. The payback period without support was less than one year. However, the Program team was prepared to fund this project to get access to the results. The Program is now funding a measurement and verification process.

These examples illustrate how different organisations have different investment criteria reflecting their different attitudes to risk, different discount rates and the other things that matter. The financial parameters summarised in Table 4.1 are further illustrations.

Table 4.1 Financial Parameters for Selected Innovative HVAC Projects

Project	Capital Cost* ($A)	Incremental Cost ($A)	Requested Funding * ($)	Funding % of Total Cost (%)	Funding % of Incremental Cost (%)	Annual Cost Reduction ($)	Simple Payback without Funding (Years)	Simple Payback with Funding (Years)
Littles Pharmacy	$12,001	$9,101	$7,601	63%	84%	$3,475	2.6	0.4
Drummoyne RSL	$44,418	n/a	$34,418	77%	n/a	$7,671	5.8	1.3
Barron & Rawson	$23,122	n/a	$11,420	49%	n/a	$2,356	9.8	5.0
Byers Meats	$399,612	$147,207	$79,922	20%	54%	$52,763	2.8	1.3
UTS 7.01 and 7.06	$115,000	$115,000	$87,000	76%	76%	$11,509	10.0	2.4
Supermarket	$135,000	$135,000	$77,852	58%	58%	$28,574	4.7	2.0

* Differences with other tables due to GST

These projects show how high funding had to be as a percentage of the capital cost for acceptable payback. Although ongoing savings are substantial, resulting in (for some) relatively short payback periods without funding, technologies are not being implemented and proponents argued that they needed funding to go ahead.

One reason for this is the perceived risk. For example, thermal storage has enjoyed at best mixed success in Australia (even though it is used extensively and successfully in Japan and the United States). Synergy argues this is because "… (the) technology has been imported but the engineering competencies to properly specify and install the technology were not similarly transferred". Property owners, facility managers and HVAC professionals are therefore sceptical about the performance and reliability of thermal storage. In particular, the failure of the existing thermal storage system to meet expectations at Drummoyne RSL has made the owner very wary of the proposed IceTower® system. This explains the request for funding of 77% of total cost (much higher relative to incremental cost) and a payback of just over one year. This will be the most expensive kVA reduction at $1,564/kVA when compared to the existing thermal storage system. However, it is a valuable demonstration. Its success (and that of the Barron & Rawson project) will be important to Byers Meats whose entire business depends on the performance of its HVAC system. As Synergy pointed out in its submission, "In businesses where refrigeration is central to the business there is a greater degree of reluctance to commit to new technologies as they bring with them a far greater increase in business risk … If a business cannot refrigerate its products then significant losses will result, even leading to business failure. In these cases businesses will have paid for the installation of the new technology and then have to pay again to replace it." From the point of view of the Program team, this is also a valuable demonstration project with estimated peak demand reduction of 300 kVA at a cost of support of only $242/kVA. This justifies funding more than half the incremental cost and agreeing to fund even though the payback without funding is less than three years.

Organisations also have different time horizons. For example, according to Munters, the required investment payback for the major supermarkets is two years and, in the absence of funding support, they will install conventional HVAC systems when they refurbish their stores.

The DICER project at UTS is being funded to 75% of its capital cost, reducing the payback from 10 years to 2.4 years. A high level of support was needed to gain internal approval for what is essentially a commercially unproven new technology, albeit one with significant potential. Although DICER can be installed in new systems, the opportunities to reduce peak demand are in existing buildings – the summer peak is an existing problem caused by existing equipment.

From the point of view of electricity consumers, energy savings are derived from lower consumption at higher peak period tariffs as well as lower total electricity consumption across all periods. However, electricity costs associated with peak demand are often small compared to the total cost of electricity consumption. Many property owners and operators are more focussed on energy efficiency opportunities than demand reduction. As a consequence, electrical equipment suppliers that are experienced in providing energy efficiency solutions are not necessarily well-versed in peak demand reduction. Further, some changes that lower peak demand can increase total energy consumption.

That other things (not just peak load) matter to electricity consumers may explain why some projects are going ahead even though they are not being funded by the Program. The University of Sydney is installing passive chilled beams in its new buildings despite a payback period of nearly 40 years. The Venue is installing its new control system as well as implementing further energy saving measures as part of its energy management policy. HyChill's refrigerant replacement activities are primarily a response to the phase-out of HCFCs.

The Last Word!

The Management Committee and the DMPP team were dedicated to making the Innovative HVAC Program a success. They genuinely wanted to find ways to reduce peak demand through innovative technologies and to showcase these technologies in the commercial sector in the metropolitan region of Sydney. It was a great opportunity for technology suppliers to showcase their products and demonstrate their value and performance. The DMPP was committed to spending the $1,000,000, but the market failed to deliver.

Not only did proponents fail to convince the DMPP that the proposed technologies would reduce peak demand, they did not provide the necessary information required to go to the next level. A great deal of hand-holding was provided by the DMPP team to assist proponents in explaining their proposed technologies. The submissions did not accurately identify peak demand reductions on extreme weather condition days, and lacked technical support in the provision of sound monitoring and verification processes. The submissions generally were from a sales and marketing, rather than a technical, approach. The DMPP continued to work as a facilitator with each proponent to extract the relevant information, however this process was very time consuming with the market place struggling to deliver.

The Innovative HVAC Program has been underway for just under two years and has achieved only limited success in identifying potential technologies. It has failed to demonstrate the impact of a variety of technologies in HVAC for the reduction of peak demand. This is after all why the DMPP and the Innovative HVAC Program were created – to provide TG and EA with confident estimates of the cost of providing financial support to customers to install demand management equipment (in $/kVA). These costs could then be compared to the cost of investing in infrastructure to increase the capacity of the electricity distribution network (in $/kVA), bearing in mind that the costs of investment vary from area to area, and project to project, and are difficult to estimate.

The last word(s) will be the job of the individual project reports that will be compiled as part of the Program through 2006 and 2007. Unfortunately, these reports will be limited in their applications and are only a proportion of what was expected from the original submissions.

The DMPP is not confident that peak demand reductions can occur through funding programs such as this, and therefore cannot confidently deliver 'good-quality' information on the demand management resources available through this process. If the DMPP was to undertake a future program to evaluate innovative HVAC technologies it would use the lessons learned from this program to develop a methodology with the following features:

- Direct approaches to property owners, to determine the level of interest and the window of opportunity for potential projects.
- Property owners, with HVAC consultants and facilitated by the DMPP, to decide which innovative solution(s) would be most suited to their particular situations.
- Individual assessments of potential projects and their funding requirements by independent HVAC consultants, engaged and paid for by the DMPP.
- Outcomes evaluated by independent HVAC consultants, engaged and paid for by the DMPP.

With this approach, property owners would install for demonstration the most appropriate technology, while clearly understanding the risks involved. Over time, they would become comfortable with new technologies and more open to considering the issue of electrical demand reduction in their decisions. Demonstrating changes in attitude is as important as demonstrating the technologies. The measurement of demand reductions, costs and savings by independent consultants would generate the accurate information required by TG and EA. However, such a program may take longer and cost more than the current Innovative HVAC Program.

Appendix 1 – Conventional HVAC technology

The Innovative HVAC Program, its projects and technologies are the substance of this report. To understand the Program it is necessary to introduce some basic science and technology. Think of this appendix as 'HVAC Technology 101'.

Electric Power: Distribution, Reliability and the Peak

Electricity is simply a way that energy moves from one location to another. The energy is carried by electrons (small negatively-charged particles found in atoms), and one of the most efficient ways to move electrons from one place to another is through metal wires. The marvel of electricity is how easy it is to transform the electrical energy into other forms of energy (heat, motion, light) at the other end.

In New South Wales, black coal is burned to produce steam to drive turbines that rotate metal coils through a magnetic field. The electromagnetic force of the field creates an electrical current. How much current is measured in amperes (A) and how much force is measured in volts (V). The higher the current, the more electrons; the higher the voltage, the more force and the further the electrical current can travel.

To cover the distances needed to travel around New South Wales, the electricity leaves power stations that are designed up to 500 kV. This is too powerful to be used by most consumers so it is progressively reduced to 240V by the transformers located in substations and on power poles. As electricity cannot be stored, the capacity of the generation, transmission and distribution system has to match the demands on the system by consumers.

Power is what is delivered through the lines and what we use to do work. Power is defined as force multiplied by current, and is measured in watts (W).

W = V x A

Power stations generate megawatts (MW) of power; consumers tend to use kilowatts (kW), but it is all watts.

1 MW = 1,000 kW = 1,000,000 W

Electrical equipment and appliances are denominated in kW and our use of power is measured in kW. However, because the power we use can be less than the power delivered due to inefficiencies in our equipment and appliances, generators and distributors think and act in 'real' power terms, ie kVA and MVA.

The difference is called the 'Power Factor'.

kW = kVA x Power Factor

Technically, the Power Factor in an alternating current circuit is the cosine of the phase angle between the voltage and the current. For our purposes, it is a number less than or equal to one. Typical Power Factors are:

a simple electric bar heater	1.0
an electric light	0.9
an electric motor	0.8

This is an important distinction for the DMPP and the Innovative HVAC Program. An electricity customer in Sydney could take action to reduce the measured load of its equipment in kW, but if the customer's equipment has Power Factors less than one, the impact on the distribution system will be lower when measured in kVA. It is kVA that matters. This is reflected in the electricity accounts of large commercial and industrial customers whose network charges (the cost of using the distribution network) have a maximum demand component measured in kVA.

The other important distinction for the DMPP and the Innovative HVAC Program is between demand and consumption (see Box A1.1).

Box A1.1 Demand and Consumption

The demand for electricity is measured at a point in time. It is the electrical load (in MVA) that the electricity consumers draw from the generation and distribution system at that time. Peak demand (or peak load) is the highest level during a period of time – a day, a week, a year.

The consumption of electricity is measured over a period of time – a day, a week, a year. It is the amount of electricity in megawatt hours (MWh) that is used by electricity consumers over that period. It is simply the sum of the load multiplied by hours.

Two identical consumption levels over a period such as a year could be associated with either a fairly constant level of demand or a high degree of variability. If it varies, as it does in the Sydney area, it is the peak level of demand that matters to generators and distributors. Extreme peaks may only happen a couple of times a year, but when they do the distribution system must have the capacity in place if the lights are to stay on.

By the same token, improvements in energy efficiency may reduce overall consumption while sometimes perversely having the opposite effect on peak demand.

HVAC Systems: Converting Energy for Comfort

Conventional HVAC systems convert electrical energy into thermal energy, ie heat. Heat is more than just temperature. There are two types of heat – sensible heat and latent heat (see Box A1.2).

Box A1.2 Sensible and Latent Heat

Sensible heat is the energy stored in materials by making them hotter. Some substances store heat better than others. If you leave a plastic chair and a metal chair in the hot sun for a few hours, which would you prefer to sit on? Water has a high capacity for storing sensible heat – think of a cosy hot water bottle on a cold night. In HVAC systems, the sensible heat (sometimes called the 'sensible load') is the heat (and cold) you can feel when the temperature goes up and down.

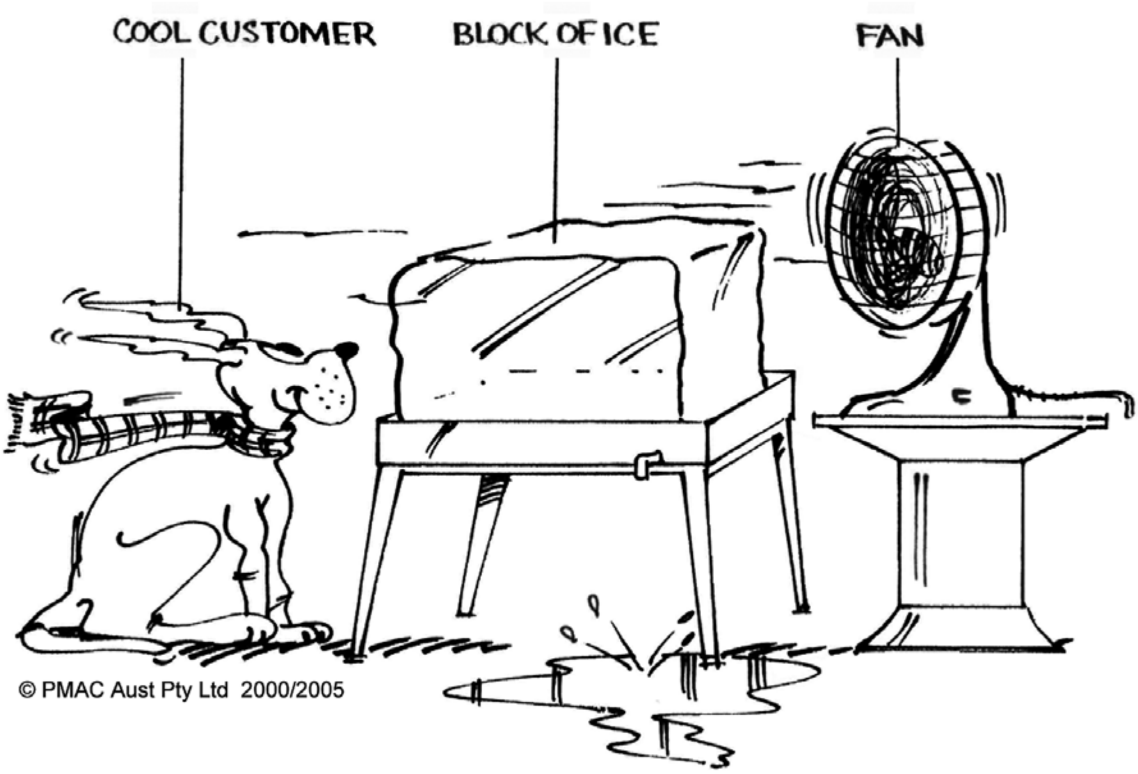
Latent heat is absorbed or released when a substance changes phase (ie gas, liquid, solid). Latent heat stores much more energy than sensible heat. Ice releases (when the water freezes) and absorbs (when the ice melts) 80 times more heat than water – think of an ice cube in a glass of water on a hot day. In HVAC systems, the latent heat (sometimes called the 'latent load') is the heat caused by moisture in the air. For a given sensible level of temperature, as measured in °C, relatively humid air holds more heat (and feels hotter) than dry air.

The total energy content of air is sometimes called its enthalpy, which is the sum of its sensible heat and latent heat.

HVAC systems use energy to control the level of comfort in homes, offices, shops and factories. We like fresh air; but we do not like to be too hot, too cold, too sticky or too dry. Although some systems take care of the entire HVAC task, this report focuses on cooling (and, to a lesser extent, ventilation). Air-conditioning for cooling in commercial buildings is the main driver of the peak summer electrical load in metropolitan Sydney.

A Cool Customer

This cool customer is enjoying the comfort of a simple cooling system.



Source: McGregor & Associates

Conventional Air-Conditioning Systems and the Summer Peak

Most commercial buildings are closed spaces, ie they do not have windows that open. Occupants rely on air-conditioning systems to circulate breathable air at comfortable levels of temperature and humidity. To do this, the system undertakes three tasks:

1# Air-handling – taking the air in from the outside, conditioning (cooling and drying) it and exhausting used air to the atmosphere.

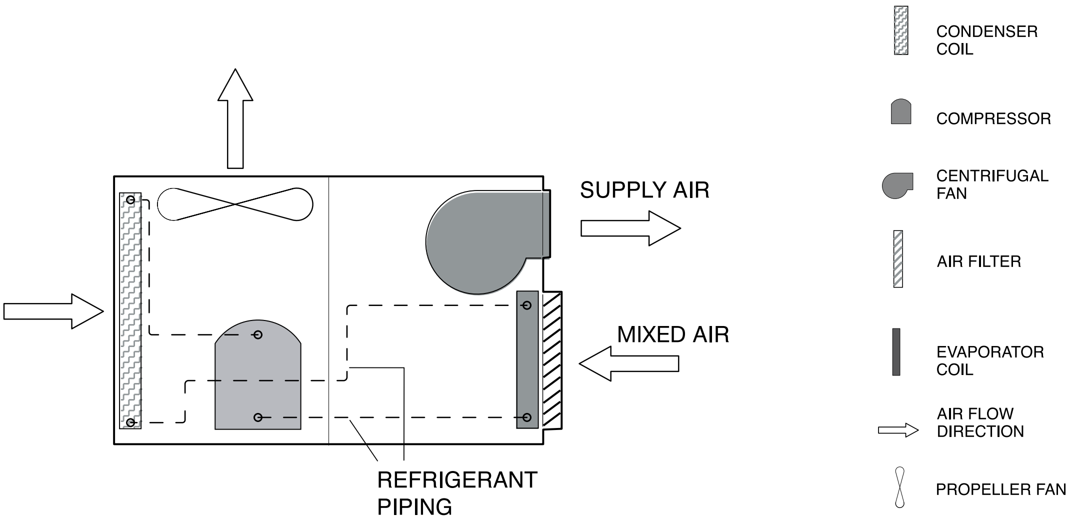
2# Refrigeration and chilling – making the cooling medium with which to condition the air and sending it to the air-handling unit.

3# Air-distribution – taking the conditioned air from the air-handling unit to the spaces that need it and bringing back the used air.

To supply conditioned air to a single room these tasks are all performed by a single packaged unit. In larger and more complex air-conditioning applications, these tasks are usually in separate locations linked by piping and ducting, all coordinated by a control system. The basic equipment in a simple, air-cooled, direct expansion (DX) room air-conditioning system comprises:

- compressor
- condenser coil
- evaporator coil
- refrigerant pipes
- air filter
- fans and motors
- ducting and vents.

Schematic: Air-Cooled Self-Contained Packaged DX Air-Conditioning Unit



Source: McGregor & Associates

The compressor is at the heart of all air-conditioning systems. It pumps refrigerant gas at pressure into the condenser coil where it liquefies. The condenser coil removes heat by warming the exhaust air. The evaporator coil absorbs heat from the outside air and cools it to make the supply air. It is sometimes called the cooling coil.

The two separate cycles – refrigerant and air – operate simultaneously, and both are powered by electrical energy. Electricity powers the compressor which converts low-pressure gas refrigerant into a high-pressure liquid, releasing heat in the condenser. The refrigerant flows in a closed system of pipes, hermetically sealed to prevent leaks. Heat is carried by the refrigerant which can store approximately 10 times more heat than water. Electricity powers the electric motors of the fans that move the air through a controlled open system of ducts and vents.

In each cycle, a fan draws return air from the room and pushes the air over the condenser coil. When air flows over the condenser coil, the refrigerant (changing phase from gas to liquid) releases heat, warming the used air. A fan expels the warm exhaust air. The refrigerant loses pressure as it changes back from liquid to gas flowing through the evaporator coil. A fan draws outside air over the evaporator and pushes the cool air into the room. The refrigerant absorbs heat and carries it through the compressor to the condenser coil. The compressor and fan motors also generate additional heat that is expelled in the exhaust air.

A Load of Cooling

The electrical load of the air-conditioning system is the amount of electrical energy demanded from the distribution network. In a simple system, the electrical load is the sum of the cooling load and the fan load. The fan motors run constantly all year round and are therefore the most significant contributor to total energy consumption. For parts of the year when the outside air temperature and humidity are within a specified range, systems can operate on the ‘economy cycle’, circulating 100% fresh air without heating or cooling. However, the cooling load varies with outside conditions, and it is this load that drives peak summer demand. In a simple system, the cooling load is the compressor load. Ignoring for the time being the impact of humidity, the cooling load depends on:

- the size of the room
- the set-point temperature
- the outdoor temperature
- the size of the air-conditioning system
- the efficiency of the air-conditioning system.

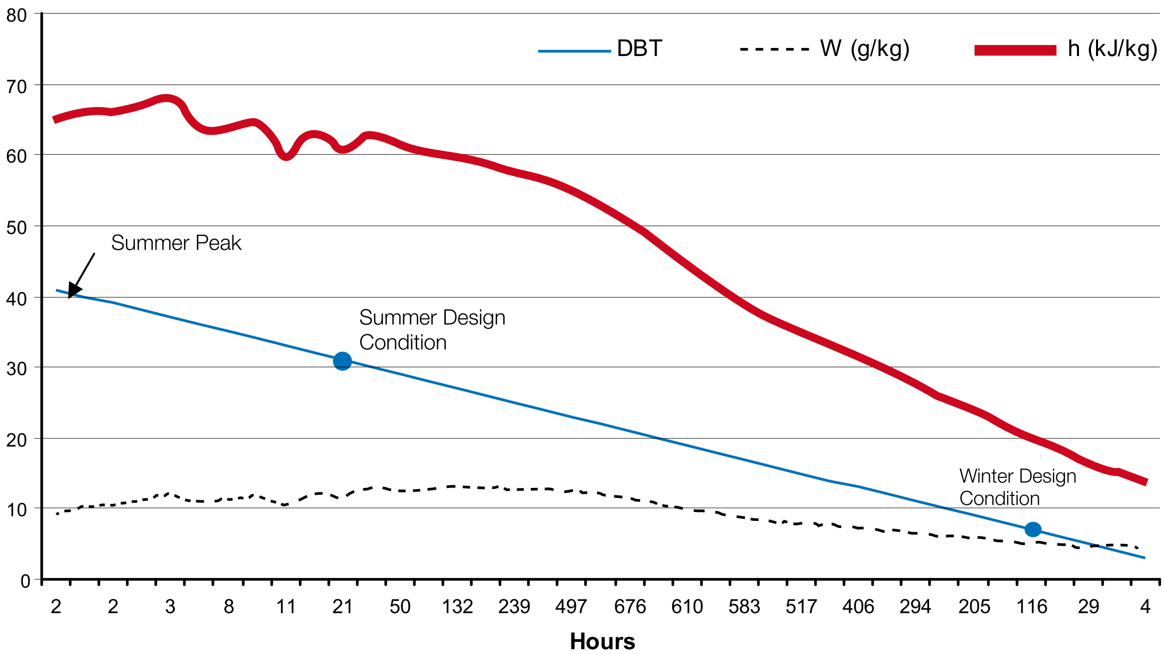
In Sydney, air-conditioning systems are mostly designed for an outside temperature of around 32°C, and are set for indoor temperatures of around 24°C in summer and 21°C in winter. In practice, this means a set-point temperature throughout the year of 22.5°C.

For a given space, the set-point temperature requirement translates to a required refrigeration effect in kWR (kW of refrigeration) which is the required cooling capacity of the air-conditioning system. kWR is the standard unit used to measure refrigeration effect. The size of the air-conditioner required (in kW) depends on its Coefficient of Performance (COP) which, for cooling capacity, is defined as:

COP = heat removed (kWR) / energy input (kW)

COP can be thought of as the number of units of heat removed by the condenser for each unit of electricity supplied. The higher the COP the more energy-efficient the condenser. Typically, a small packaged air-conditioning unit has a COP of about 2.5. To maintain a set temperature of 22.5°C, the compressor cycles on and off. At any given moment on a ‘design’ day in Sydney, some compressors are running and some are at rest. When the temperature rises above 32°C, the compressor stays on for longer, operating continuously at very high temperatures. The compressor motor over-heats and the COP falls. When all the systems in Sydney are running at full capacity at the same time, the load on the electrical distribution network peaks. Extreme temperatures are experienced for about 60 hours each year – less than 1% of the time. However, the electrical distribution network has to be able meet this level of demand 100% of the time.

Sydney Outdoor Conditions throughout the Year



Source: University of Technology Sydney

The horizontal axis shows the number of hours in a year the different outdoor conditions are experienced. The blue line represents the dry bulb temperature (see Box A1.3). The dotted line represents humidity (w). The red line represents enthalpy (h), or the total heat content that people experience.

Humidity Matters

Comfort is not just related to temperature. Humidity and air movement also affect how comfortable people feel in the conditioned space. Moist air feels warmer than dry air and air movement is cooling. The 'comfort zone' can be illustrated on a psychrometric chart (see Box A1.3 and chart on page 41).

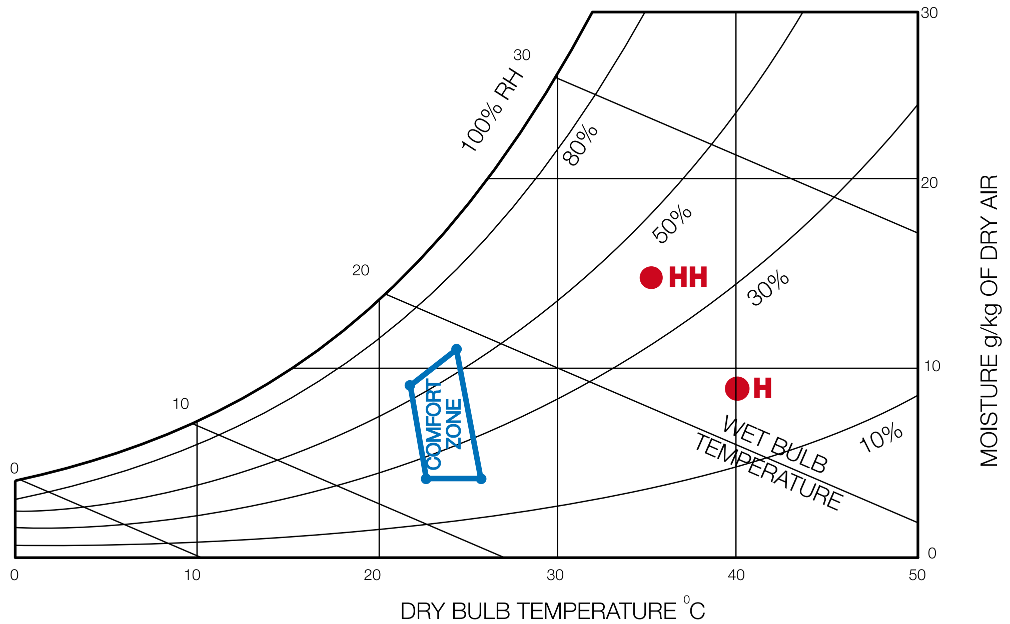
Box A1.3 Psychrometry: Measuring Temperature and Humidity

Psychrometry is a branch of physics concerned with the measurement and determination of the thermodynamic properties of air and water vapour mixtures.

Air is therefore a mixture of dry air and water vapour. The 'dry bulb' temperature (DBT) of air is that indicated by an ordinary thermometer. Its humidity ratio in grams per kilogram (g/kg) is the ratio of the mass of water vapour to the mass of dry air. Its relative humidity (RH) is the ratio of the partial pressure of water vapour to the saturation pressure of water vapour at the same dry bulb temperature and barometric pressure as the air being measured. In other words, the air is saturated with water vapour when the RH is 100%. The 'wet bulb' temperature is the lowest temperature that can be obtained by evaporating water into the air at constant pressure. The name comes from the technique of putting a wet cloth over the bulb of a mercury thermometer and then blowing air over the cloth until the water evaporates. Since evaporation takes up heat, the thermometer will cool to a lower temperature than a thermometer with a dry bulb at the same time and place.

These technical terms are best understood in relation to each other on a psychrometric chart.

Psychrometric Chart: Comfort Zone and Metropolitan Sydney Summer Peaks



Source: McGregor & Associates

Box A1.3 continued

The level of sensible heat in the air is measured left to right along the horizontal axis by the dry bulb temperature.

The level of water vapour in the air is measured bottom to top along the vertical axis by the humidity ratio.

The relative humidity is represented by the curves convex to the right-hand lower corner at which point RH is 0%. The farthest curve to the upper left represents RH of 100%.

The wet bulb temperature is represented by the diagonal lines (top left to bottom right).

The shape of this chart illustrates that, kilogram for kilogram, there is more water vapour in hot air than cool air. Further, the wet bulb temperature is equal to the dry bulb temperature at 100% RH. As the level (and proportion) of water vapour falls, the wet bulb temperature also falls.

Hot and/or humid outside air is an 'uncomfortable' mixture of dry air and water vapour. This is shown at points H (for hot) and HH (for hot and humid) in red on the chart. The comfort zone is outlined in 'cool' blue.

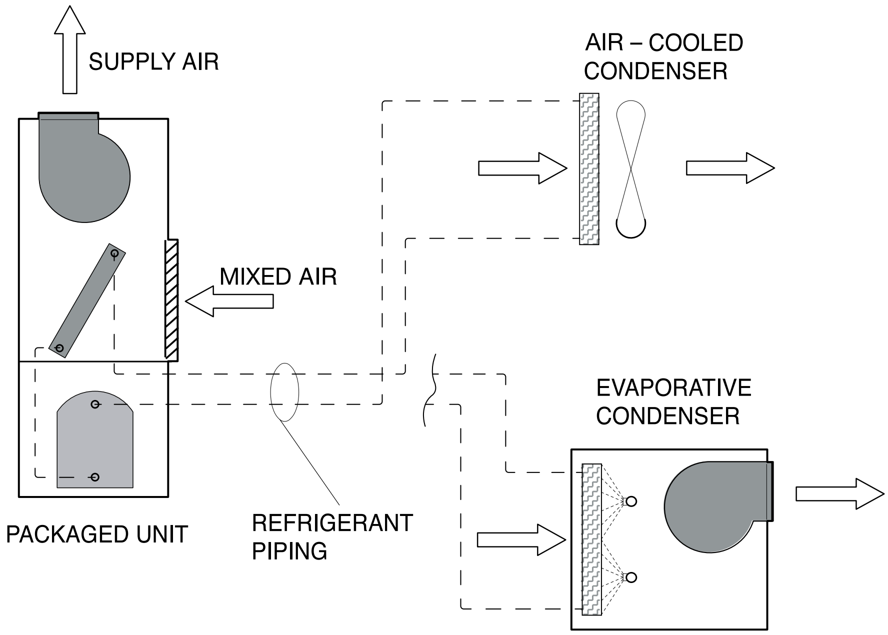
Summer electricity demand peaks are experienced as much on days of high humidity as on days of high temperature. On 30 January 2003, the peak demand day in the summer of 2002-03, the relative humidity was 86% at 6 am.

The cooling coil in conventional air-conditioning systems removes both sensible and latent heat, ie it cools and dries the air. If the outside air is hot and dry, the air-conditioner will make the air too dry; if the outside air is very humid, only some of the moisture is likely to be removed and the air will feel warmer. With simple home air-conditioners, people usually turn the knob to a colder temperature and end up too cold. In more complex commercial systems, humidity is addressed in a different way and this is taken up later in this appendix. In the meantime, this section introduces the main components of commercial air-conditioning systems.

Cool, Clear Water

The condenser is the component that rejects the heat from the system by cooling the refrigerant. The refrigerant can be cooled by the return airflow blowing over the condenser coil (air-cooled); the refrigerant passing through a closed container with tubes of water (water-cooled); or simultaneously blowing air and spraying water over a series of coils (evaporative).

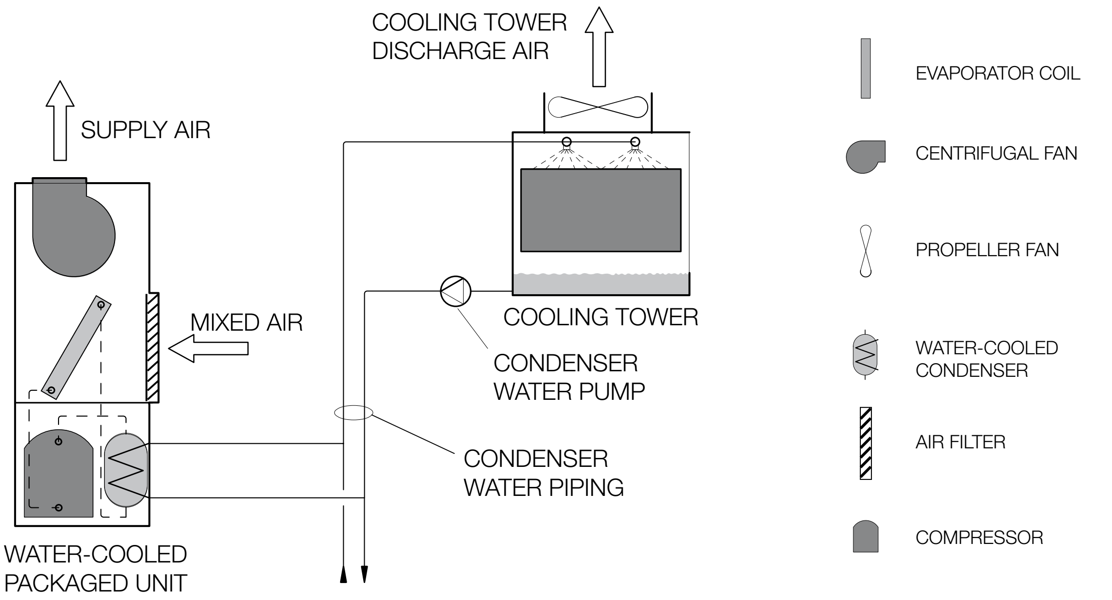
Schematic: Packaged Air-Conditioning System with Remote Condenser (Air-Cooled or Evaporative)



Source: McGregor & Associates

A water-cooled system uses a cooling tower to transfer the heat from the water to the atmosphere. There are three cycles operating simultaneously – air, water and refrigerant. As the heated water falls through the tower, it tumbles over plastic (timber in older systems) raised surfaces that break up the water and release the heat into air, which rises to the top of the tower where it is expelled by an exhaust fan. The cooled water at the base of the tower is then pumped back to the condenser to do it all again; however, some is lost to evaporation and fresh water is added to make up the volume.

Schematic: Packaged Water-Cooled Air-Conditioning System



Source: McGregor & Associates

Even though a cooling tower adds to the electrical load through the introduction of pumps, a water-cooled system uses less power than an air-cooled system because it needs smaller fans. Air-cooled systems use large fans to blow the cooled air across the condenser coil. Even though the system uses about 20% less energy, it uses a lot of water as most of the water is lost to evaporation in the tower. Further, water-cooled systems carry the risk of Legionella and are more costly to maintain. A poorly-maintained system adds to power demand by adversely affecting efficiency. Increasingly, commercial buildings are being converted to air-cooled systems. This has the potential to add to the electrical demand from HVAC systems. Just as with a simple room air-conditioner, high temperatures and humidity significantly affect the performance of cooling towers and evaporative coolers. For example, cooling towers can only cool to 2°C above wet bulb temperature.

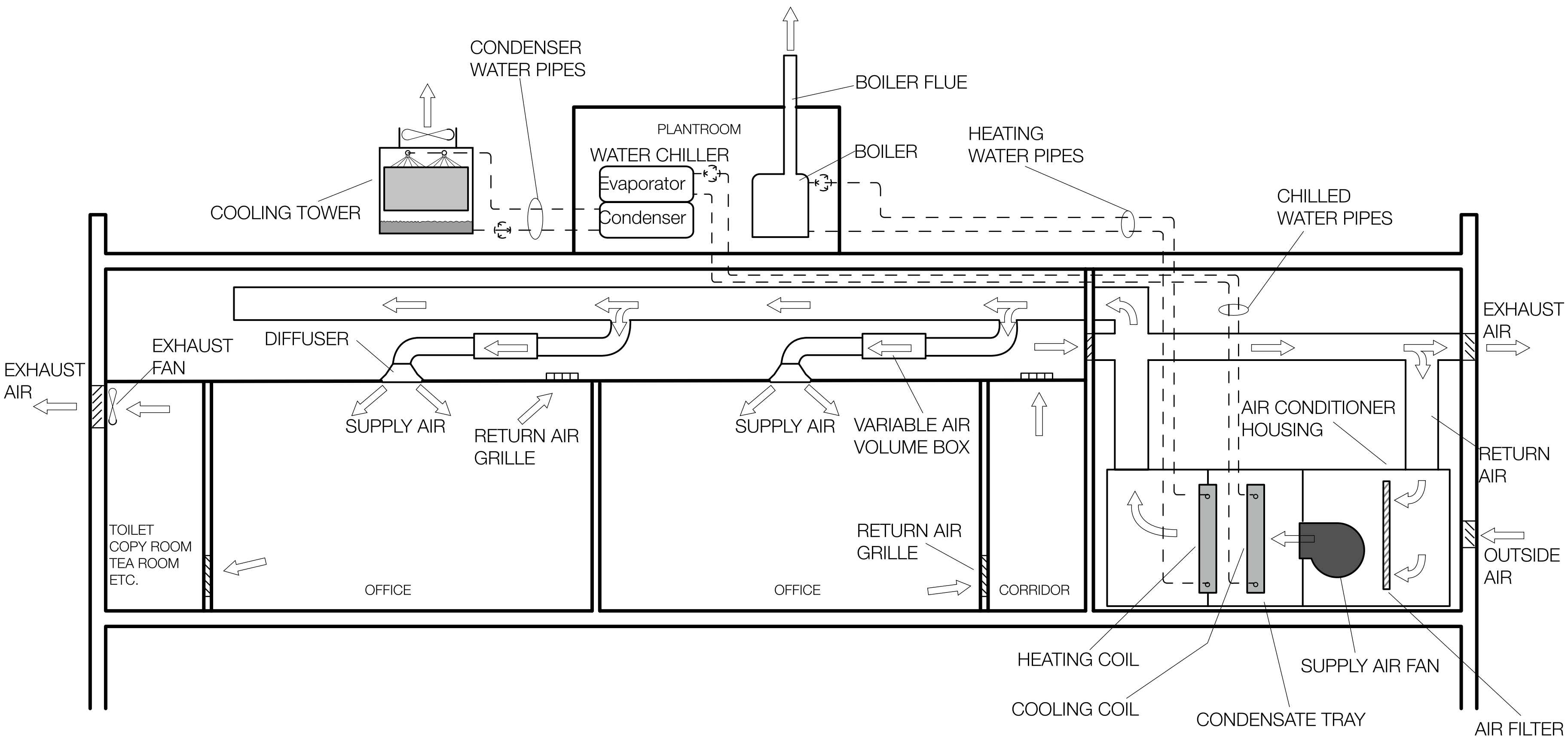
Large Commercial HVAC Systems

In packaged air-conditioning units, the air-handling and the cooling equipment is housed in a single unit. It may have a remote condenser, a remote condensing unit (condenser and compressor), or a remote cooling tower. Mostly they are direct expansion (DX) where the primary coolant, the refrigerant, is the cooling medium in the cooling coil.

Alternatively, a secondary coolant – usually chilled water or brine – is pumped through the cooling coil. In these systems, a chiller (sometimes called the refrigeration plant) operates as a 'water-conditioning' system. Just like a simple air-conditioning unit, it includes a compressor, a condenser, an evaporator and piping. Instead of cooling and warming air, it cools and warms water. The cooled water is then pumped to the air-handling unit. Chillers have a special condensing water circuit for transferring the condenser heat for either air-cooling or water-cooling.

Chillers are typically used in large HVAC systems because they can supply a number of air-handling units spread across a large area. In these large applications, it is costly and potentially hazardous to pipe refrigerant across the entire site, and it is more convenient to have remote access to the refrigeration plant for maintenance.

Schematic: Typical Central Plant Air-Conditioning System



Source: McGregor & Associates

Large commercial systems undertake four tasks

1# Air-handling – equipment draws in unconditioned 'outside' air, mixes outside air and 'recirculated' air, filters this mixed 'ventilation' air and cools it, and exhausts the 'return' air (that is not recirculated) to the atmosphere.

2# Refrigeration and chilling – the refrigeration plant processes (compresses, condenses, expands) the refrigerant and chills the secondary cooling medium (water or brine) and pumps it to the air-handling units.

3# Air distribution – equipment circulates conditioned 'supply' air to the living or working space and removes 'return' air from the space.

4# Control – automatic controls coordinate the operation of the HVAC equipment to maintain the condition of the internal spaces.

The air-handling units use electricity to power fan motors in the different airstreams. The plant uses electricity to power compressors as well as auxiliary motors for condenser fans, cooling tower fans and pumps in the condensing water circuit. The air-distribution units use electricity to power fan motors delivering supply air to the conditioned space and return air to the air-handling units. The control system uses only a very small amount of power but its performance is crucial in determining total HVAC system electrical demand.

With large commercial systems, the whole is more than the sum of the parts. For example, a small plant with a large load needs bigger fans to circulate more air. System design affects overall COP. An efficient chiller could have a COP of seven but inefficient fan motors and/or inefficient design could reduce the HVAC system COP to as low as three. Ideally, the system should be designed for the unique conditions of the commercial premises. Within the building, different spaces will have different needs at the same time. If one needs more cooling than another, the system may be trying to heat and cool at the same time. Further, some conventional air-conditioning systems control humidity by over-cooling and re-heating the air, adding to the electrical load.

Other features that affect the HVAC system's electrical demand include:

- Whether it has constant (CAV) or variable (VAV) air volume – VAV uses less power.
- Whether the motors are constant or variable speed drive (VSD) – VSD means the system can be fine-tuned to deliver the correct air quantity to each internal space, using less power.
- The proportion of fresh air in the ventilation airstream – the required minimum was recently increased, adding to the cooling load and lowering the operating performance of some conventional systems.
- Using reverse-cycle units to replace chillers and gas heater – such units are much less efficient particularly under peak load conditions.
- The extent to which energy is recovered – recall that air-conditioning is basically removing heat (ie energy) from the inside of a building to the outside, and in most conventional systems this energy is dissipated into the atmosphere.

Therefore, from a technical perspective, there is considerable scope to reduce the load HVAC systems put on the electricity distribution system, and this was demonstrated in the range of technologies proposed under the Innovative HVAC Program. These technologies are described in Appendix 2 Innovative HVAC technologies.

Appendix 2 – Innovative HVAC technologies

Although not all projects proposed in the initial Expressions of Interest are still part of the Innovative HVAC Program, most involved innovative technologies with the potential to reduce peak electrical demand in the inner suburbs and CBD of Sydney. This appendix includes the technologies still involved in the Program as well as promising technologies that for various reasons are not participating in the Program.

One way to significantly reduce electrical demand would be to knock down all the existing buildings and rebuild the city using 'energy-responsive climate-adaptive' commercial buildings. Phase Change Materials (building materials for frames and walls that absorb energy when the room is hot and release it when it is cool) are being developed. When combined with passive solar features, energy-responsive buildings impose only a small HVAC load on the electricity supply system. This is a lot more expensive and disruptive (but more comfortable and convenient for occupants) than the strategies canvassed in the *NSW Electricity Demand Study – 2003*. The Study identified 2,073 MW of potential summer peak demand reductions including 1,200 MW from restricting the use of air-conditioners in 'comfort cooling' applications. A less drastic passive approach is window glazing. This was one of the technologies initially proposed by the University of Technology Sydney in its EOI. Window glazing and other passive solutions reduce both demand and consumption all day, every day. Passive solutions include the use of insulation, shades and blinds, and/or raising the set-point temperature to reflect the season (higher in summer, lower in winter) so that the system does not switch on and off as much but occupants are still comfortable.

However, the Innovative HVAC Program's aim is to identify active solutions to the problem of peak load. The EOI document identified a set of possible innovative technologies for guidance, although the list was not meant to be exhaustive. These included:

- chilled beams
- gas-fired systems
- ice and chilled water storage
- air and/or water heat recovery
- high-efficiency compressors
- variable speed drives
- control systems
- high-efficiency motors.

To a large extent, these were the technologies in the projects submitted to the Program. In this report, they are grouped according to how they lower peak electrical demand, as follows:

1# Fuel Substitution

2# Load Shifting

3# Pre-Conditioning

4# Taking Control

5# Improving COPs.

A2.1 Fuel Substitution

The obvious way to reduce peak demand for electricity is to use another form of energy to power the air-conditioning system. Even though HVAC systems still need electricity to power fan motors, the cooling load can be powered by any fuel. Two very different fuel substitution technologies were proposed under the Innovative HVAC Program: a gas-powered chiller within a conventional system and a more innovative absorption chiller powered by cogenerated heat from a gas-powered generator.

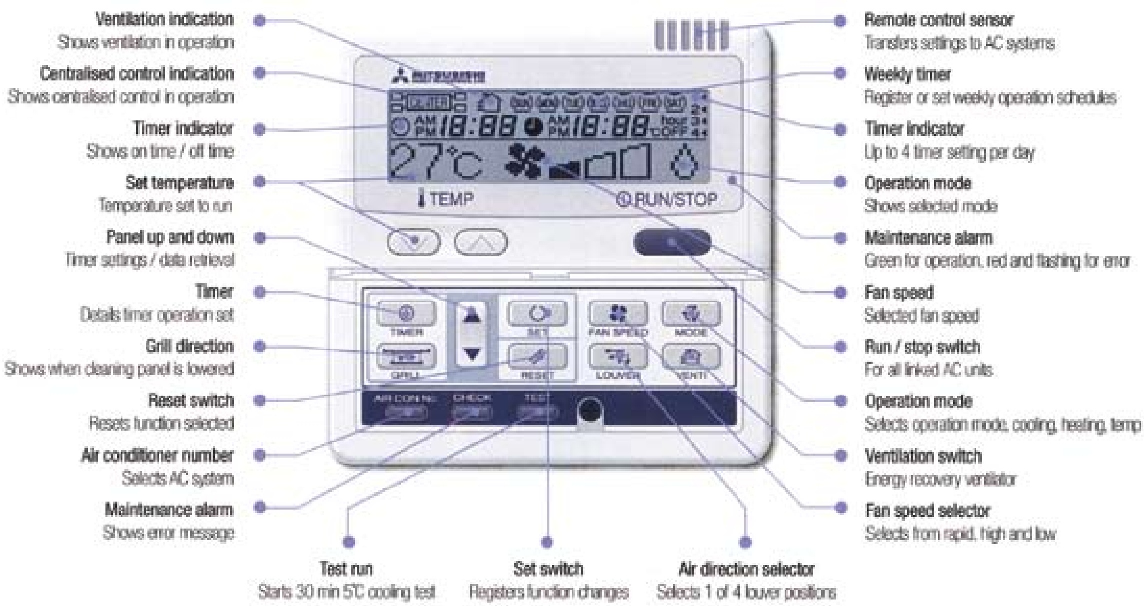
A2.1.1 Advanced GHP

Advanced GHP is Mitsubishi Heavy Industries' gas-engine driven multi-indoor unit climate control system. This unit was proposed by Discount Air for the refurbishment of the Grand United Building in Sydney's CBD.

The original 1930s electrical supply is rated at 1,200 amps per phase and is drawing 800 amps per phase, of which 200 amps is drawn by the air-conditioning. However, the building is only partially air-conditioned and the refurbishment plan includes fresh air ventilation which meets the requirements of the Australian standards plus air-conditioning for the entire building. A suitable conventional electrically-powered HVAC system would draw 1,000 amps per phase, requiring a new substation with a capacity of at least 720 kW.

Discount Air proposes to install a gas-engine system with electrically-powered fan motors which will draw 140 amps per phase at peak. The Advanced GHP incorporates a sophisticated control system that allows the condition of each space to be individually set, as well as a variable speed compressor that adjusts to the demands of the building.

Mitsubishi Heavy Industries' Advanced GHP Space Climate Controller



Source: Mitsubishi Heavy Industries Ltd

A2.1.2 Cogeneration with an Absorption Chiller

Investa Property Group is redeveloping 33 Bligh Street in Sydney's CBD for its sister company, Investa Properties Limited – the building owner. The owner requested the building refurbishment include the installation of 100% stand-by power. This was to be provided by two 1,500 kVA diesel generators complete with underground fuel storage. When funding from the Innovative HVAC Program became available, Investa proposed replacing one of the diesel generators with a gas-engine generator and, instead of an electric-powered chiller, installing a 1,080 kWR Li-Br (lithium bromide) absorption chiller.

In periods of peak demand, the cooling load on the absorption chiller would signal the generator to fire. That means the total electrical load of the building would be met by stand-by power during extreme weather conditions. This is equivalent to as much as 1,750 kVA in peak demand reduction. At other times, a conventional electric HVAC system would operate.

With a reciprocating engine, heat is recovered from the engine's jacket cooling water, lubricating oil circuits and exhaust through heat exchangers. An absorption chiller uses heat (instead of a compressor) to maintain the pressure differences in the refrigerant circuit. The refrigerant is circulated from the evaporator through an absorber, where it absorbs a lithium bromide solution, to a concentrator where the refrigerant is evaporated out of solution. This is cooled in the condenser and expanded into the evaporator again to chill the secondary heat transfer medium.

With few moving parts, an absorption chiller requires minimal maintenance. However, with a relatively low COP (0.8 in the Investa proposal), an absorption chiller is not very efficient and is usually only installed where there is waste heat available. In terms of peak demand reduction, when linked to a gas-fired generator, the low operating performance is not an issue.

A2.2 Load Shifting

Load shifting can reduce peak summer demand by using off-peak electrical power for the key refrigeration task. Unlike fuel substitution, load shifting does not eliminate the entire peak load because electricity is still needed to power fan motors and other equipment. However, it shifts the most significant power requirement from the peak daytime hours to overnight when the overall HVAC load in the city is much lower.

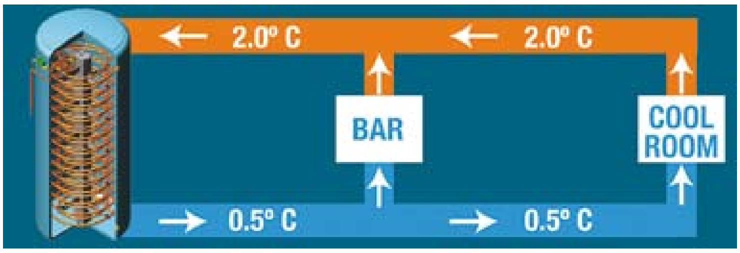
Because the cooling medium is chilled overnight, its cooling energy needs to be stored until it is needed to absorb heat during the day. This means storing either chilled water or ice. Ice uses a lot less space but can mean higher overall energy consumption.

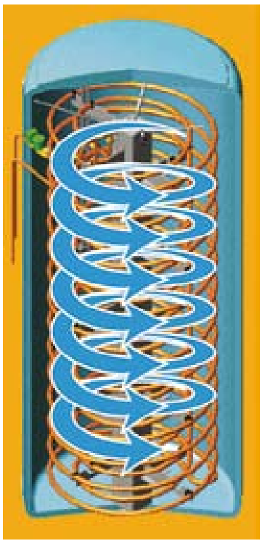
The Innovative HVAC Program received one set of proposals using storage technologies from Synergy Thermal Technologies with diverse applications for its IceTower®.

A2.2.1 IceTower®

The IceTower® is an insulated cylindrical metal tube that is filled with water at installation. The tower contains a double helical evaporator coil. A standard DX refrigeration unit pumps refrigerant to the coil at night to build ice inside the tower where it is stored until it is needed for cooling during the day. When needed, the ice is used to cool water that is piped via a closed circuit to the required tasks such as air-conditioning, refrigeration or machinery.

IceTower® in Action





Source: Synergy Thermal Technologies Pty Ltd

The return water creates a vortex action and burns the ice off evenly. The higher the cooling load, the quicker the ice burns off.

The IceTower® uses internet controls, allowing remote monitoring and temperature control. The system can be set to anticipate high loads (using weather-based load profiling), making sure the system does not run out of ice and the DX refrigeration stays off during the peak. These controls also mean that electricity companies can monitor or control the time of use of power by the system's air-cooled condensers.

Unlike conventional cooling technologies, IceTower® operates under all conditions; it is not affected by high temperatures or high humidity. Unlike other ice storage technologies, IceTower® can provide chilled water at different temperatures from as low as minus 6°C (with the addition of glycol) up to 30°C. This development broadens the applications of ice thermal storage by enabling medium-temperature applications such as some industrial processes. For example, dry-cleaning machines require temperatures of about 15°C, a temperature that cooling towers struggle to provide in the summer peak.

At Littles Pharmacy, IceTower® replaced a standard 20 kW fresh-air packaged air-conditioner that was over 10 years old. At best, the old unit was only providing 12 kW of effective air cooling. It was particularly ineffective at the rear of the shop in the dispensary area. Additional cooling was provided by a Fujitsu under-ceiling split unit with capacity of 14.1 kW cooling and 15.8 kW heating. This unit was retained for heating. The owners had planned to replace the old packaged air-conditioner with a second, 6 kW, split unit in the dispensary. The old system was working very hard during summer peak periods. The expected peak load reduction was 19 kVA.

A similar load reduction is expected for Barron & Rawson plastics factory where two smaller units and a new chilled water fan coil will replace the old 20 kW packaged unit servicing the office area. The peak load reduction there is estimated at 25 kVA.

At Drummoyne RSL, four 60 kWh IceTowers® will replace four 40 kWh existing thermal storage units that cannot keep up with a peak refrigeration requirement of 540 kWh.

"On hot days, the beer is poured at more than 2.5°C which is unacceptable!"

The new IceTower® system will operate the condenser for only 15 hours per day (6.7 hours off-peak and 8.3 hours shoulder period) and not during peak periods. Using a clock in the controller, the IceTower® is instructed to build ice only if required during shoulder periods, and to perform a full build of ice during off-peak periods. The larger storage capacity provides more than 34 kW of refrigeration for the seven hours of peak during the day. This is more than enough to satisfy the average maximum load of 22.5 kW on even the hottest day, while reducing peak demand by 20 kVA (compared to the existing thermal storage system; 40 kVA compared to the alternative replacement system).

At Byers Meats' new refrigerated processing works, Synergy will install three large IceTowers® with six 80 kW DX refrigeration units and associated equipment to refrigerate the entire factory of 1,070 square metres and air-condition the office of 105 square metres. This is expected to reduce the peak electrical demand by 300 kVA when compared with a conventional refrigeration and HVAC system.

A2.3 Pre-Conditioning

The summer peak demand from HVAC systems, in particular the primary refrigeration plant, is due to the need to condition extremely hot and/or humid outside air in systems designed for relatively cooler and drier 'normal' summer conditions. Electrical demand from the primary plant can be reduced by 'pre-conditioning' the outside air, ie reducing heat and moisture levels before the air flows over the conventional cooling coil. This lets the cooling coil do what it is designed to do, thereby reducing total HVAC system demand during the critical peak period. Pre-conditioning units can be retrofitted to reduce peak demand or fitted to new systems where they reduce the overall size of the HVAC system needed for the task.

Pre-conditioners may remove sensible heat (pre-cool) or latent heat (dehumidify) or both. Some technologies reduce the electrical load further by recovering waste energy from the exhaust air and using this to reduce humidity. The key principles in pre-conditioning are evaporative cooling and air-to-air heat recovery.

Evaporative cooling lowers the dry bulb temperature of air by bringing it in close contact with water. The heat in the air evaporates the water, which involves a change of phase from liquid to vapour. Evaporative coolers may be associated with problems of corrosion and contamination. Indirect evaporative cooling uses water sprays to cool the exhaust air, which is then used to cool the ventilation air through an air-to-air heat exchanger. By spraying the exhaust air rather than the ventilation air, there is less risk of contamination. Evaporative pre-cooling of ventilation air removes only sensible heat. Therefore, it is most effective in hot, dry conditions. With indirect evaporative cooling, heat from the heat exchanger can be used to dehumidify as well as cool the outside air.

Air-to-air heat recovery can lower both temperature and humidity by transferring the heat and moisture between the ventilation and exhaust airstreams. The effectiveness of air-to-air recovery systems varies across applications; however, they usually lower the load on primary refrigeration plant and increase the load on fan motors. Heat recovery units need larger fans because they cause a loss of pressure in both ventilation and exhaust airstreams. The most common recovery unit is the rotary energy wheel regenerator (also called heat wheel or enthalpy wheel). A desiccant film coating on the surface of the wheel absorbs moisture from the outside air as it passes through one side of the wheel, then carries the moisture until it meets the less humid exhaust airstream where it 'desorbs'. The desiccant is a hygroscopic chemical, ie it attracts and absorbs moisture from the air. Desiccants need heat to regenerate, ie reduce the moisture they absorb. There are three types of desiccant dehumidifiying systems:

- solid desiccant on a rotating wheel
- liquid desiccant in a direct open circuit
- liquid desiccant in a dual indirect closed circuit.

The key parameters of these systems are their efficiency in removing sensible and latent heat, and the degree to which they are prone to contamination and corrosion.

Heat wheels use a silica gel to absorb moisture from the outside air. They produce a drier, but warmer, ventilation air and need a heat exchanger to cool the ventilation air. They also need heat to regenerate the desiccant and are particularly suited to applications with waste heat. Heat wheels can lead to contamination from the desiccant (it needs to contact the humid air to do its work) and are prone to cross-contamination between the airstreams. Contamination is also an issue for units in which the liquid desiccant, usually lithium chloride, removes moisture directly from the ventilation air in an open circuit. The health effects of inhaling desiccants are not well known. This risk is reduced in a dual indirect closed circuit where the desiccant is used to remove moisture from the exhaust airstream, and a combination of indirect evaporative cooling and air-to-air heat exchange is used to cool and dry the outside air.

There were six pre-conditioning technologies in the projects submitted under the Innovative HVAC Program.

A2.3.1 Airconomist

The Airconomist unit intermittently evaporates water sprayed on a large mesh in front of the cooling surface of the air-conditioning system. The Airconomist units proposed by Phase6 will be placed in front of air-cooled evaporator coils in the air-handling units of Electroboard' s head office. According to Phase6, the Airconomist reduces the temperature of the outside air by between 10°C and 15°C. Water spray durations and frequencies are constantly adjusted by the 'intelligent' ' controller to optimise performance and minimise water consumption, and Airconomist can be interfaced with Rippleband DLC and Phase6 controls (see A2.4 Taking Control in this appendix).

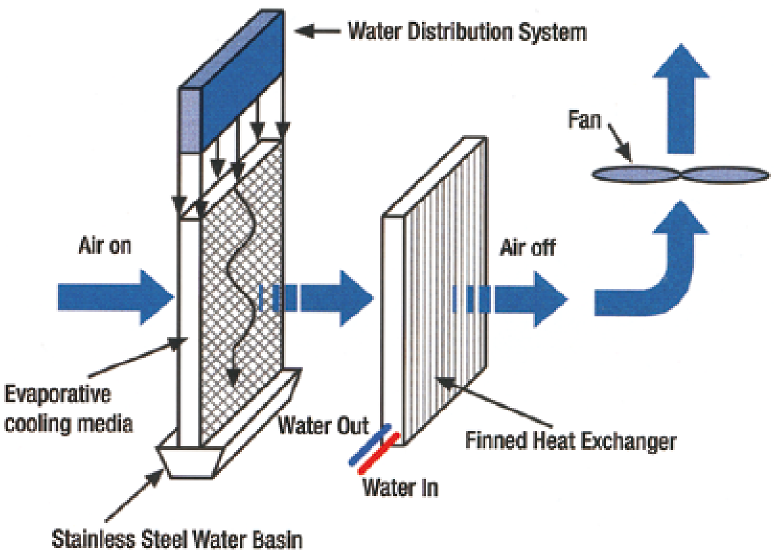
A2.3.2 Dricon

The Dricon unit proposed by Muller Industries integrates an evaporative pre-cooler with an air-cooled condenser. It replaces an open-circuit water-cooled system with an air-cooled system that uses less energy and demands less power than a conventional air-cooled system.

In the pre-cooler system, pads made of rigid hardened celluloid are saturated with water. The outside air passes over the pads, lowering its temperature to 2°C or 3°C above wet bulb temperature. The pre-cooled air is then sucked through a conventional finned heat exchanger cooled by a refrigerant.

Dricon Principle of Operation

(Note: refrigerant, not water, is the cooling medium in new applications)



Source: Muller Industries Australia

With the Dricon unit, the pre-cooler does not spray water directly onto the heat exchanger, avoiding the risk of corrosion; nor does it generate an aerosol so there is no transmission of bacteria in the supply air.

At the Alcatel facility, Muller Industries replaced three cooling towers which were at the end of their useful lives with Dricon systems. The three direct expansion systems include two with 270 kWR compressors and one with a 190 kWR compressor, all using R22 refrigerant. On a 35°C day in Alexandria, the HVAC system delivers 730 kWR of cooling. Before the installation of the Dricon system, power input was 232.5 kW and peak load was 245 kVA. Muller Industries estimate that the Alcatel facility HVAC system with the Dricon units installed will deliver 805.1 kWR of cooling from a power input of 213.6 kW with peak load reduced to 224.8 kVA. The reduction of 20.2 kVA represents 8% saving in kVA demanded by the HVAC system at peak.

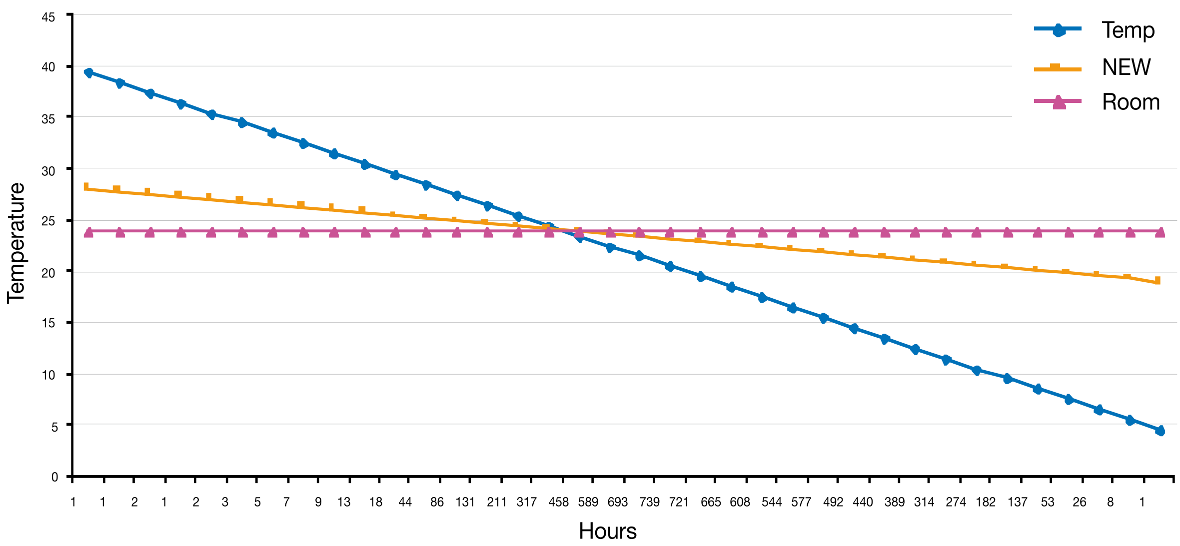
To the extent that building owners convert from water-cooled to air-cooled systems in response to concerns over Legionella, potentially adding to the peak load, wider application of the Dricon system could mitigate the extra load.

A2.3.3 Econovent

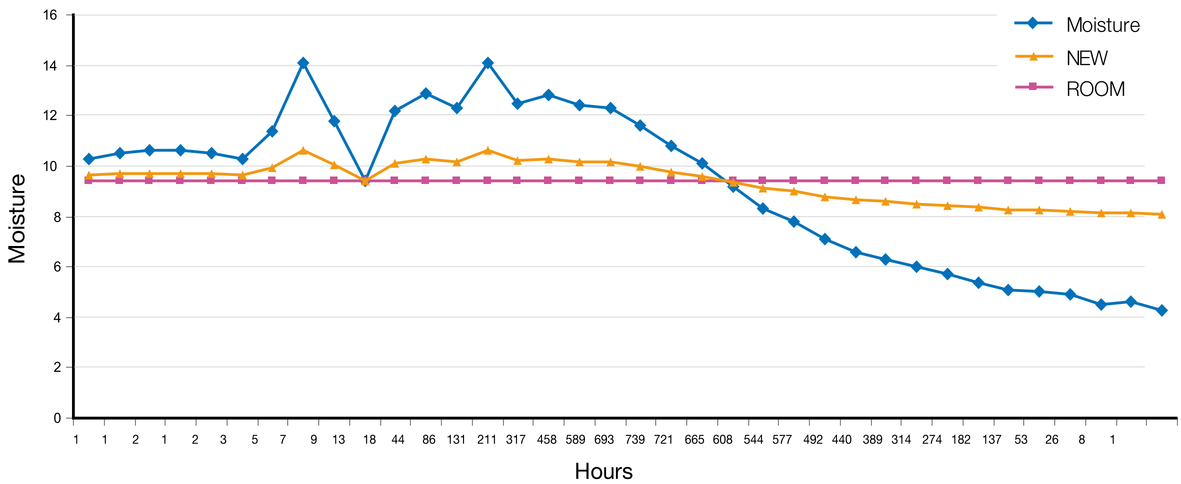
Econovent is an air-to-air rotary enthalpy heat exchanger which transfers heat and moisture from the exhaust air to the supply air as it rotates. The supply air flows through one half of the heat exchanger and the exhaust air flows through the other half in the opposite direction.

Tempering Extremes with Econovent

Temperature Distribution



Moisture Distribution



Source: Munters Pty Limited

The blue line in the first graph shows the temperature distribution throughout the year in Sydney. The yellow line is the desired room line – the constant design conditions. The pink line shows the temperature of the air after the application of Econovent. The gap between the blue line and the pink line indicates the amount of energy savings.

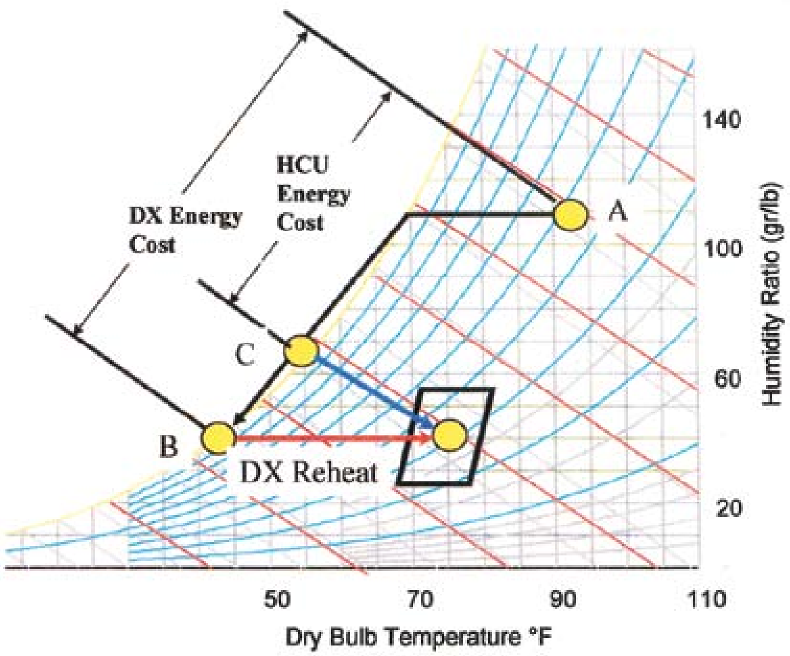
Similarly, the blue line in the second graph shows the mean coincidental moisture content distribution throughout the year in Sydney, and the yellow shows the moisture level of the air after the application of Econovent.

Munters proposed to fit Econovents as part of the new HVAC system of a 20-storey commercial building. It estimated that a conventional water-cooled system with a central plant and eight air-handling units processing 100% fresh air would have a primary refrigeration requirement of 1,390 kWR and a peak load of 310 kVA. By installing an Econovent in each of the air-handling units to cool and dry the outside air before it passes over the cooling coil, the HVAC system's refrigeration requirement reduces by 22% to 1,091 kWR. Peak demand reduces by 66 kVA to 244 kVA. However, the Econovent slows the flow of air and the system requires larger fans, adding an estimated 6 kVA to peak demand. The overall impact is a reduction of 60 kVA, which is nearly 20% of the conventional HVAC system's peak load.

A2.3.4 Humidity Control Unit HCU6000

The humidity control unit HCU6000 adds a desiccant dehumidifier to a conventional DX air-conditioner. The dehumidifier pre-treats the outside air, reducing the humidity before it enters the air-conditioning system. The desiccant wheel's titanium silica gel is regenerated by the recycled waste heat from the condensing unit, adding only minimally to the electrical load.

Psychrometric Chart: With and Without HCU6000



Source: Munters Pty Limited

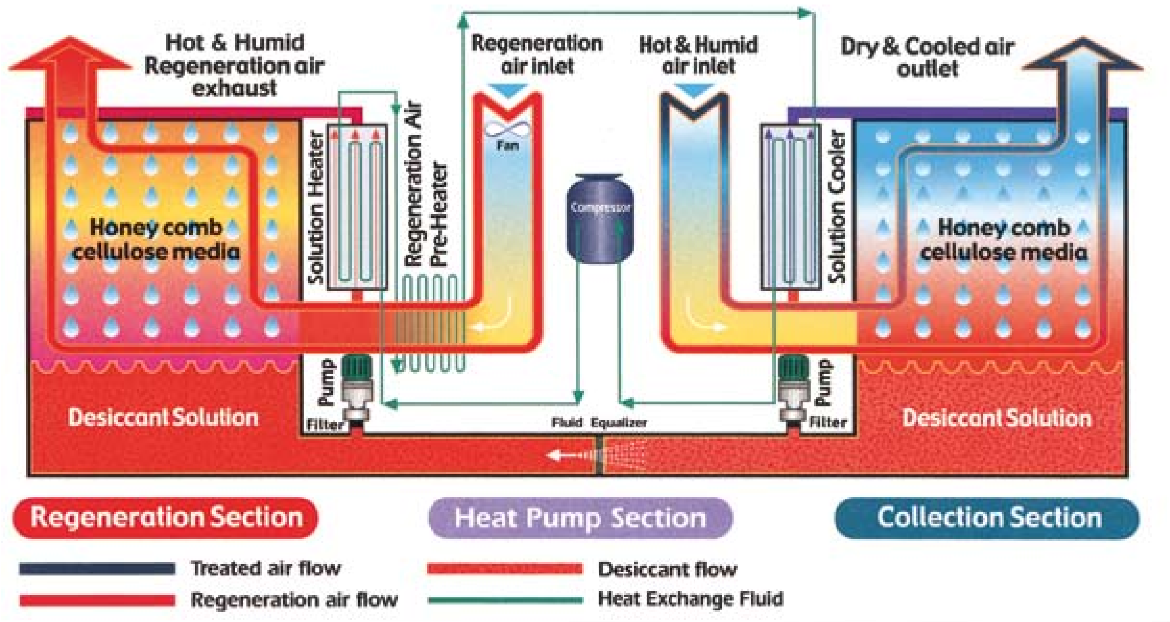
With the HCU6000 (6,000 cfm), the system cools from point A to point C instead of over-cooling (point C to point B) and re-heating (point B to Comfort Zone).

Munters estimate the reduction in peak load from including an HCU6000 at the proposed supermarket site to be 62 kVA (40% of the HVAC system load). This was based on a high-temperature and high-humidity day in Sydney with a ventilation air mix of 20% fresh and 80% recirculated. The peak demand reduction would be much higher in applications requiring 100% fresh air.

A2.3.5 DryKor TAC

In its EOI, Energy Conservation Systems (ECS) claimed that the DryKor TAC (thermal air-conditioner) unit removes moisture from outside air before it is cooled in a standard air-conditioning system. At the heart of the TAC is the DryKor liquid desiccant dehumidifier. The DryKor process passes outside air through a cooled lithium chloride solution where it loses both heat and moisture. The heat can be used to regenerate the desiccant, which becomes warm and diluted. The desiccant is cooled using the refrigeration plant – either chilled water or refrigerant.

Schematic: DryKor's Liquid Dessicant Pre-Conditioning Process



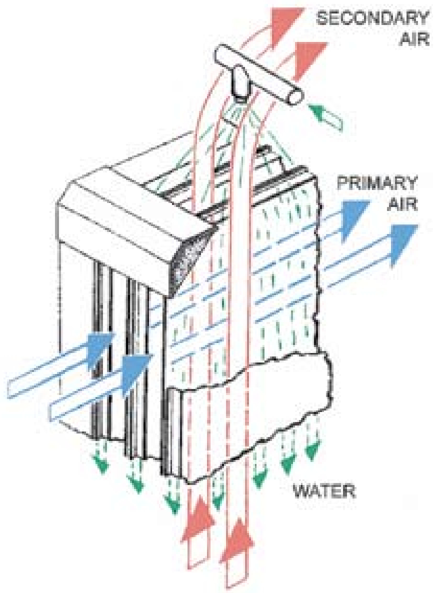
Source: DryKor Ltd

Although ECS did not proceed with an RFP, it indicated that – in a commercial application in metropolitan Sydney – the TAC could be ducted to the outside air inlet of an air-handling unit, utilise the existing cooling tower to cool the desiccant and draw heat from an existing hot water boiler system to regenerate the desiccant. Two TAC-10 units are estimated to reduce peak load by 50 kVA.

A2.3.6 Dual Indirect Cycle Energy Recovery (DICER)

Dual Indirect Cycle Energy Recovery (DICER) combines a polymer plate heat exchanger (PPHE) for air-to-air energy recovery with an indirect evaporative cooler. Stand-alone, the indirect evaporative cooler can effectively condition the outside air when it is not too hot or humid. On hot and humid days, outside air is passed through one set of passages in the PPHE. The polymer absorbs the sensible and latent heat from the outside air. This partially-cooled dry air enters the existing conventional air-conditioning system, which only has to take care of the sensible heat load as most of the latent load is eliminated by the DICER unit. The heat exchanger transfers the heat and moisture to the exhaust airstream, which is passed through a different set of passages. The heat is then recovered from the exhaust air by water sprays. It is this heat that is used to dry the outside air. The exhaust air that leaves the building is cool and moist.

PPHE Cross-Section

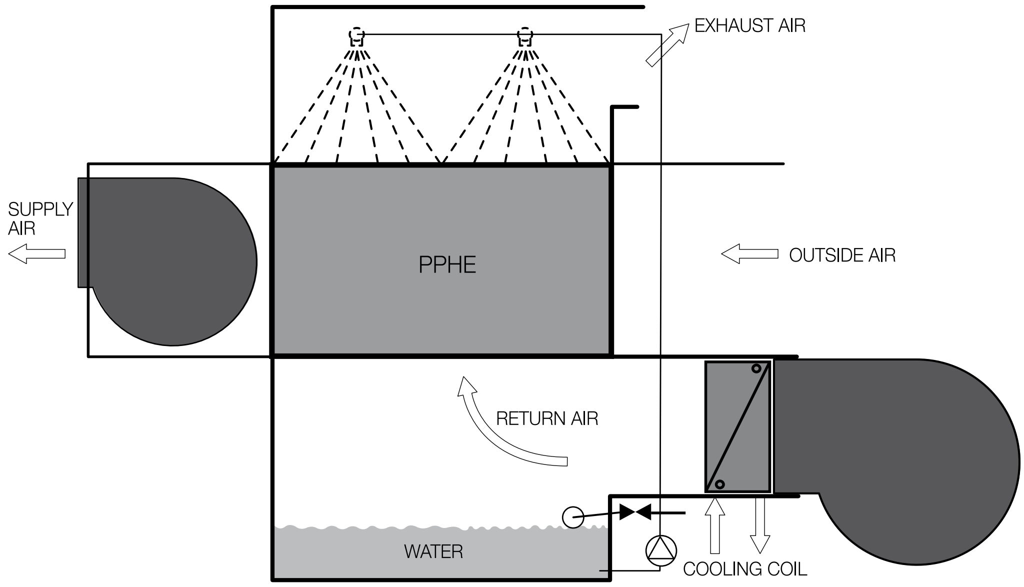


Source: UTS/FICOM

Therefore, the DICER system simultaneously recovers energy from the exhaust airstream, and cools and dehumidifies the outside air component of the ventilation air. Each part of the energy reduction is taken into consideration including the condensate from the PPHE and integrated cooling coil. The cold condensate water is trapped and mixed with the water being sprayed into the exhaust air in the heat exchanger. DICER also reduces the water used by the cooling tower in a large air-conditioning plant. This means that DICER can reduce peak demand with lower energy consumption and lower water consumption.

The DICER system proposed by UTS will also cool the return air with a cooling coil that draws chilled water from the main refrigeration plant. This means the exhaust airstream is cool and dry before it enters the PPHE.

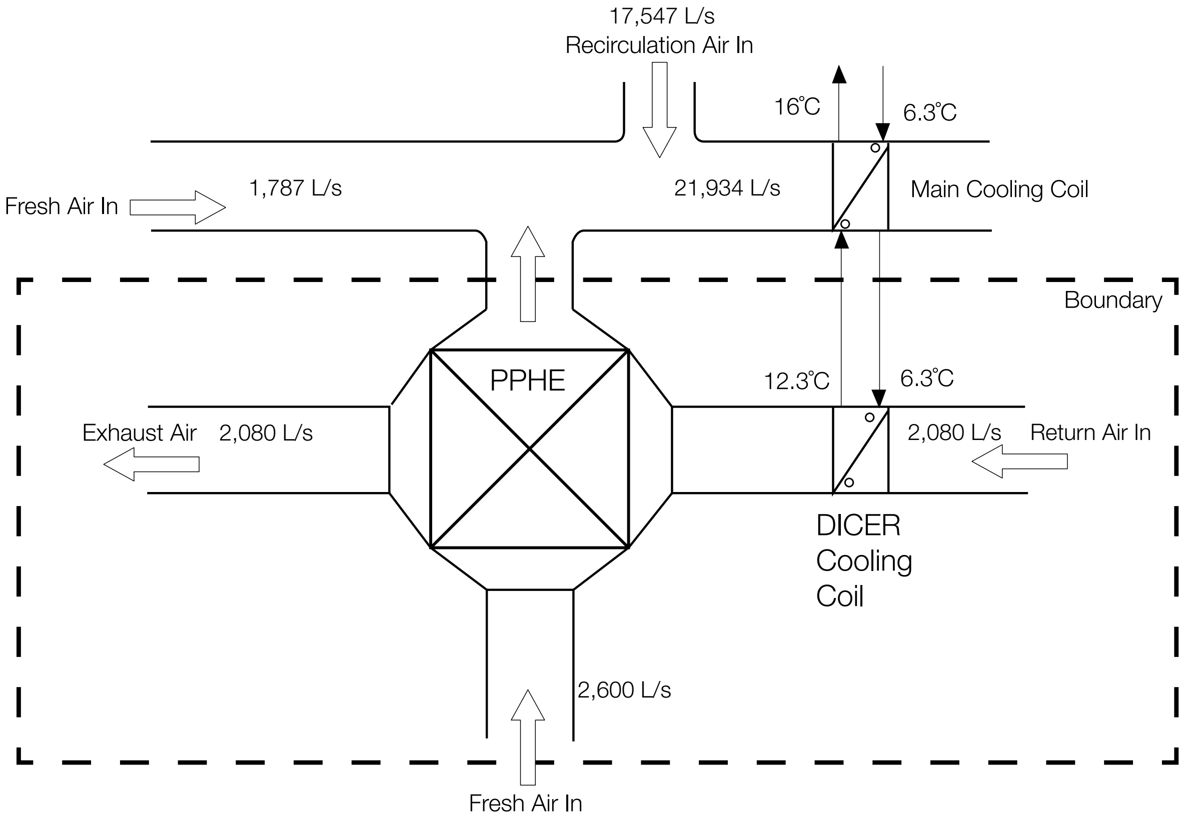
DICER Working Principle



Source: UTS/FICOM

At the UTS Tower Building, air-conditioning is performed by a central chilled water plant and 10 air-handling plants located at different levels. Two of the air-handling units are located in plant rooms on level seven (7.01 and 7.06). These units take in a mix of outside and recirculated air, pass this air over cooling coils containing chilled water (produced in the central plant on level one), and send the cooled air to the lecture theatres and offices on level seven. At the same time they exhaust used return air back to the outside. Although the DICER system can be applied to situations requiring 100% fresh air, the supply air in the Tower Building is 20% fresh and 80% recirculated. This mix will be retained for this demonstration project. The UTS system is set for a temperature of 24°C (+/- 1°C) and 50% relative humidity (+/- 5%). It operates for 15 hours (6 am to 9 pm) every day. For the demonstration, the DICER units will be used to pre-treat 60% of the outside air component. (The amount of air that can be pre-treated is limited by the space available in the plant rooms.) The pre-treated air will be mixed with recirculated air from the rest of the building and some untreated outside air.

Schematic: Air Flow for Room 7.01



Source: UTS/FICOM

The demand in kVA from the Tower Building is 1,415 kVA, with 60% from the chiller, 24% from the fans, 10% from the cooling tower and 8% from the pumps. Installing DICER units in plant rooms 7.01 and 7.06 is estimated to reduce peak load by 71 kVA, about half of which is due to reducing the load on the cooling coil in the plant room and the other half due to reducing the load on the main chiller. The UTS project includes installing a high-efficiency fan motor with variable speed drive in room 7.01, which adds 5 kVA to the demand reduction.

UTS estimate that if DICER units were installed in all 10 plant rooms in the Tower Building, mixing the same proportions of pre-treated, untreated and recirculated air, the demand reduction would be about 300 kVA or 20% of the building's total demand. The extent to which other commercial premises could achieve these (or higher) reductions by installing DICER units in their air-handling units would depend on the configuration of the system, its settings and the composition of the ventilation air. When applied to a new installation, the demand reduction (and savings in energy consumption, water usage and cost of installation) would be greater.

A2.4 Taking Control

The importance of a properly functioning control system cannot be overstated. According to AIRAH[2], "Poorly designed, badly commissioned and improperly maintained automatic controls are undoubtedly the greatest cause of wasted energy in many air-conditioning systems … Very often simultaneous requirements for heating and cooling can be incorrectly perceived by controls that have deviated from their set-point." Direct digital control is becoming the standard.

A2.4.1 Rippleband DLC

Phase6's Rippleband DLC control systems are used with its Airconomist, Shaw Method and Phase6 technologies.

Distribution line carrier (DLC) systems allow power-saving features such as economising, intelligent start, setback and load cycling.

When used with Airconomist, the control system adjusts the frequency and length of the water spray to the ambient temperature. Once the set-point is reached the spray is automatically switched off.

When interfaced with Phase6 (see A2.4.2 Phase 6), the controller cycles the compressor in response to electricity pricing and load signals, either through power line ripple control or broadband internet connections.

A2.4.2 Phase6

Phase6 HVAC controls are designed to reduce summer peak demand by responding to price and load signals from TG and EA. Phase6 allows either direct load control (specified equipment is automatically turned off for a limited time) or voluntary load control (electricity consumer validates the request).

Phase6 estimates demand reductions of between 20% and 40% for short periods of time, depending upon the type of air-conditioner, switchable loads and the thermal capacity of the building.

In widespread application there is scope to stagger the signals across metropolitan Sydney over the hours between 10 am and 5 pm on working weekdays.

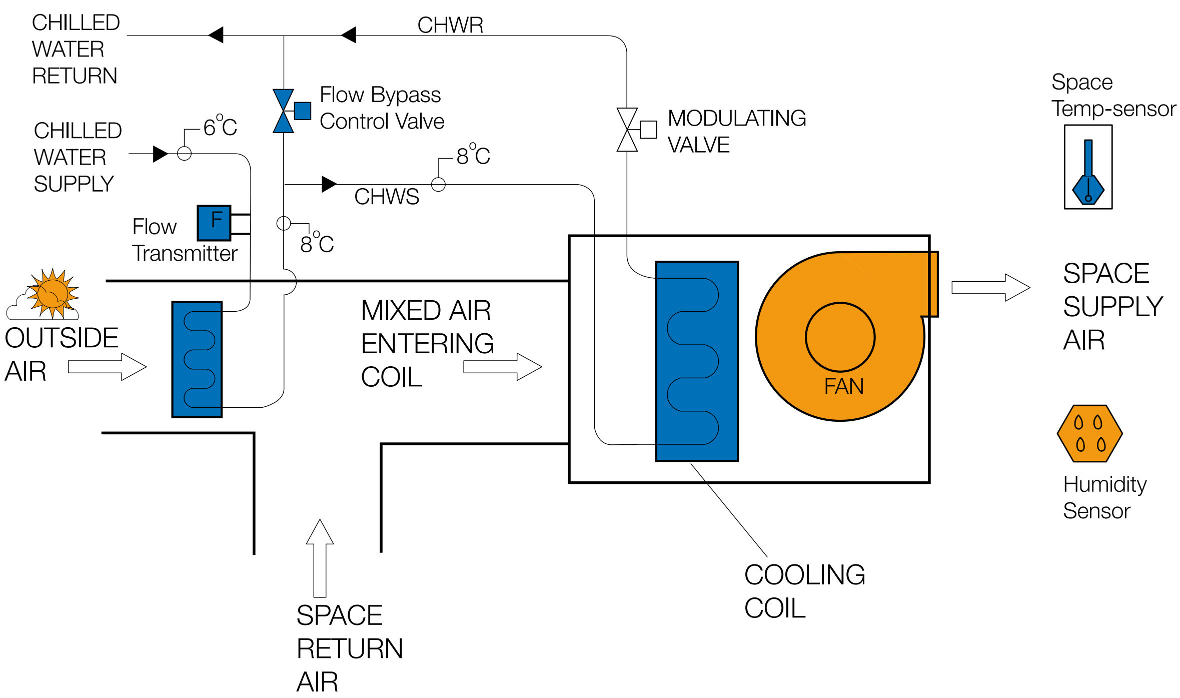
A2.4.3 Shaw Method

For the AGC House project, Phase6 is proposing a combination of DLC, Phase6 and the Shaw Method.

The Shaw Method is an air-conditioning control system that varies the evaporator temperature by adding a dehumidifying coil at the outside air intake. This innovation could also be thought of as a pre-conditioner.

[2] *HVAC & R An Introduction*, AIRAH Application Manual DA8, 1998, p. 44

Schematic: Conventional Air-Handling System Incorporating the Shaw Method



Source: Air Con Serve Pty Ltd

With the first coil reducing the humidity, the second coil only has to control the temperature. The first coil receives the coldest water to provide the greatest potential for moisture removal. The Shaw Method of control reduces (and can eliminate) the need to over-cool and re-heat.

Each space is controlled separately and independently with a humidity sensor, valves in the chilled water supply and chilled water return, and two cooling coils – one (a double) for the recirculated air and one for the outside air. To achieve this level of control, the system needs to include a variable speed compressor.

Phase6 estimates the Shaw Method combined with Phase6 will reduce peak demand at AGC House by nearly one-third.

A2.4.4 Turnstile Control

The proposal from the Venue took a different approach to taking control. It is an approach that could be applied to other large venues with similar usage patterns.

The Venue comprises a concert hall, its foyers, some smaller theatres, and offices. The concert hall is by far the biggest space requiring a large volume of fresh air when occupied. The air in the concert hall is controlled by a central plant and three air-handling units. The four foyers each have their own air-handling unit connected to two other plant rooms. Each space is controlled by a Teletrol Building Management and Control System. Although the Venue is open most days and evenings of the year, the concert hall and foyers are only used occasionally during normal office hours (9 am to 5 pm weekdays). The system is currently set to deliver 100% fresh air at all times, but during the day much less fresh air is needed to meet the desired level of comfort and compliance.

In its EOI, the Venue proposed to link the existing sensors that count the number of people visiting the Venue to the HVAC controls. The number of people in the space will control the proportion of fresh air delivered in the supply air. Carbon dioxide sensors will be used to make sure there is enough fresh air at all times.

To facilitate this new approach, the project will mean extensive modifications to the control system, as well as other modification such as fitting variable speed drives to the fan motors.

The Venue's management estimates that the peak demand reduction would be greater than 250 kVA, or 11.5% of the total HVAC system's peak electrical load.

A2.5 Improving COPs

To a greater or lesser extent most of the innovative technologies available to reduce peak demand also improve equipment and/or system COPs. For example, whenever the cooling load is reduced, the COP of the refrigeration plant is improved. Similarly, motors with variable speed drives have higher COPs. This can also be achieved by replacing key equipment such as the chiller with a more efficient unit. Similarly, Power Factor correction can improve appliance COPs. However, for effective demand reduction the system COP also has to be improved.

The focus here is on two technologies: one that can significantly improve the system COPs of conventional systems and one that uses a different approach altogether.

A2.5.1 Hydrocarbon Refrigerants

In the HyChill proposal, R22 will be replaced by HR290 – a natural hydrocarbon refrigerant – in a standard packaged air-conditioning and heat pump system.

The story of hydrocarbon refrigerants is an example of ‘all that is old is new again’. R22 is a single hydrochlorofluorocarbon (HCFC) compound. HCFCs were introduced to replace CFCs from the 1970s. Chlorofluorocarbons (CFCs) were popular replacements for hydrocarbon and other refrigerants in the middle decades of the 20th century because they are not flammable. However, findings in the 1970s that CFCs cause ozone depletion and, later, that they contribute to global warming led to their phasing out. HCFCs have a relatively low impact on ozone, but still have a high global warming potential. R22 has an atmospheric lifetime of 15 years.

In Australia, production and imports of CFC refrigerants ceased on 1 January 1996, except where an essential use license is granted. The Australian Government introduced controls on the import and manufacture of HCFC refrigerants from the same day. Substantive supply (imports) will cease by 2020 with only very limited supplies then available until 2030 to service remaining HCFC-dependent equipment.

HR290 is 95% propane (a liquefied petroleum gas). It lasts less than one year in the stratosphere and its ozone depletion potential is nil. More importantly from the point of view of the Innovative HVAC Program, HR290 is 50% more efficient than R22 in conducting heat and uses up to 20% less power to reach temperature set-point. Although the power reduction varies with HVAC system design, scientific tests based on the properties of refrigerants show an increase in COP of 10% when propane replaces R22.

Although the estimated peak demand reduction is only 10 kVA, refrigerant replacement is a ‘drop-in’ solution (ie there is no need to make any other changes to the system) with the potential for easy widespread application. The issue of flammability, however, remains.

A2.5.2 Chilled Beams

Chilled beams take advantage of the fact that ‘hot air rises’. The beams circulate chilled water through elements mounted on the ceiling. By circulating higher temperature water at 16°C (assuming this is above the room dew point) compared to 6°C in a conventional system, chilled beam systems use smaller chillers and do not need to re-heat. By using fans only to circulate fresh air, they use smaller fan motors. This translates into lower demand, especially in summer peak conditions. As people, their equipment and their activities generate heat, the warm air rises to the ceiling where it circulates around the beam. As it cools, the air falls. The radiant cooling from the beams supports the process. ‘Active’ chilled beams use fans to push the air around the beams; ‘passive’ chilled beams let the air circulate around the beams naturally. In both systems, 100% fresh air is introduced into the space separately via mechanical fans. If the outside air is very humid, it may create condensation on the beams. Therefore, a dehumidifier is often added to the system.

The University of Sydney plans to install chilled beams is its new Central Building in City Road South. Low-temperature chilled water will be pumped from a central roof-mounted air-cooled chiller through a closed-circuit primary cycle. This will be used to generate high-temperature chilled water in a closed-circuit secondary system through heat exchange with the low-temperature chilled water. By installing the passive chilled beam system instead of a conventional air-cooled VAV system with electric re-heats, the University of Sydney estimated a peak load reduction of more than 300 kVA.