



Researching the researcher

A short report on an HVAC&R “research activity” survey, conducted by AIRAH, writes Vince Ahearne, M.AIRAH.

SHORT AND INFORMAL

As part of a recent initiative, AIRAH conducted a short and informal survey on activity within the HVAC&R research space in Australia.

We asked academia and industry what research is being undertaken in the HVAC&R and related fields, by whom, what the perceived research gaps are, and where the unused capacity within research institutions might be.

With 57 individual responses, the level of interest and survey completion was somewhat of a surprise. The quality and

quantity of research being undertaken in areas related to HVAC&R was more than expected.

The purpose of this short report is to provide a snapshot of current and potential future HVAC&R research activity, and share some of the informed responses to the survey. The information provided in this report was submitted by survey respondents and is passed on in good faith.

WHO RESPONDED?

Fifty-seven replies were received from individual researchers, representing

multiple researchers operating in 21 different institutions and three private companies.

HEAT IS THE NEW COOL

Perhaps not surprisingly, a lot of research is taking place in a variety of applications to turn heat into coolth or, more broadly, to transform energy from one form to another – efficiently and cheaply.

Solar energy, geothermal energy, waste industrial energy, recovered commercial energy – all have potentially viable applications.

Survey respondents came from the following research organisations

Australian National University	University of Adelaide
CSIRO	University of Melbourne
Curtin University	University of New South Wales
Deakin University	University of Queensland
Flinders University, Adelaide	University of South Australia
Massey University	University of Southern Queensland
Private companies	Queensland
Queensland University of Technology	University of Sydney
RMIT University	University of Tasmania
Sustainable Built Environment National Research Centre	University of Technology, Sydney
Swinburne University of Technology	University of Wollongong Victoria University

Likewise for solar refrigeration and air conditioning, hybrid photovoltaic/thermal air and water systems, heat-driven cooling cycles, adsorption and absorption, co-generation and tri-generation. There is also an interest in transforming energy for heating, cooling, and electricity generation at the macro scale and the micro scale, and everything in between.

LOW-EMISSION TECHNOLOGIES

There is also considerable research activity in other low-emission technologies, related to heating and cooling including:

- Increasing the capacity and efficiency of existing air conditioner and heat pump technology, heat exchangers, and solar collectors.
- Micro-scale and nano-scale heat transfer and fluid flow.
- Ground-sourced and geothermal-based cooling and heating systems, radiation-based air conditioning systems.
- Phase-change materials, sensible and latent energy storage, integrating phase-change materials with air conditioning and refrigeration.
- Thermal improvements in glazing and building fabric, building sealing and air exchange, integrating phase-change materials and photovoltaics into buildings.

- White roofs, green roofs, shade effects, passive architectural low-emission solutions.

LOW-EMISSION PRACTICES

Low-emission practices are also the subject of research and investigation. It's not necessarily the technologies that will be used in systems and buildings being researched, but the methods of evaluating, designing and integrating that technology, including:

- Building energy simulation, building energy efficiency and sustainable building design.
- Integrated design practice – tools, technology, techniques.
- Rooftop solar and rainwater analysis tools.
- Retrofitting buildings and improving the performance of existing systems.
- Derivation of updated HVAC&R design temperatures.
- Updating the STEPS and Sustainable Design Scorecard (SDS) sustainability rating tools.
- Analysis of NatHERS and NABERS results for better understanding of energy use in buildings and energy-efficiency opportunities.
- Sealing of buildings and distribution systems.

INDOOR ENVIRONMENT QUALITY (IEQ)

The indoor environment is also an area of consistent research efforts. Current work includes:

- Thermal comfort – thermal comfort analysis; adaptive thermal comfort models for: natural ventilation, air conditioning and mixed-mode buildings.
- Instrumental measurement of fundamental parameters of IEQ.
- Indoor air quality (IAQ) – influence of ventilation and filtration on IEQ.
- Ventilation requirements of zero-energy homes.

REFRIGERATION

It's not, however, all about building, air conditioning and ventilation. There is also a considerable amount of research going on in the commercial/industrial refrigeration sector.

- Food – Thermal properties of foods, food cooling and freezing, carcass spray cooling, and optimising airflow around packaging and storage systems.
- Technology – International IIR research, energy harvesting in refrigeration systems.
- Practice – Refrigeration heat loads, energy efficiency of cold stores.

OPTIMISE EVERYTHING

With the current focus on energy efficiency “optimise” is a word that was extensively used by the researchers responding to the survey. Trying to optimise outcomes is a large part of what they do. Some of the activity around system optimisation includes:

- Evaluations and comparisons of system types (e.g. UFAD versus VAV versus chilled beam) for optimal performance.
- Optimising systems using controls (smart controls, integrated and advanced controls); optimising control algorithms.
- Optimising IAQ and ventilation, optimising ventilation and energy efficiency.
- Integrating HVAC efficiency into building energy efficiency and building efficiency into precinct energy efficiency.

OTHER AREAS

It is not all about energy efficiency and conservation, however. There are many other research areas and fields within the HVAC&R space. Some of the other areas covered and not yet mentioned include:

- Microbiology – Characterisation and health risk of legionella and mycobacterium avium complex (MAC) in water-distribution systems.
- Fire control – Water-mist fire-suppression systems.
- Noise reduction within air conditioning ductwork.

THE PEOPLE IN ALL THIS HVAC&R STUFF

The researchers are not forgetting about the people side of HVAC&R – of course, these are the technical service providers but also the owners, the operators and the occupants, who are all part of the energy-efficiency equation, and also need to be addressed. Several researchers are involved in addressing the relationship between people and technologies including:

- Understanding the relationships between building management, building occupants and building energy efficiency.
- Understanding the drivers and motivations behind energy efficiency and how to incentivise uptake.
- Post-occupancy evaluation and perception of IEQ.
- BOSSA – Building Occupants Survey System Australia is an Australian Research Council (ARC)-funded IEQ assessment system for Australian office buildings.
- Attributes that employers look for in architects, engineers and construction professionals.

THE RESEARCHERS' WISH LIST

As with all areas, researchers are often not able to work in all of the fields that they think are important, beneficial, or interesting. Some of the areas that researchers think should be looked into more deeply in the future include:

- Optimal design of pipe and duct systems for energy efficiency.
- Carbon efficiency of all refrigerants.

- Evidence-based performance of HVAC&R innovations, evaluation of energy efficiency interventions and before-and-after performance analysis.
- Rooftop greenhouse air treatment systems, combining green roofs and air treatment.
- Quantified relationship between IEQ and productivity.
- Quantified relationship between IEQ and building energy efficiency.
- Understanding the impact of radiant temperature on occupant comfort.
- Interaction between thermal, IAQ, lighting and acoustic discomforts.
- Personal control systems, and advanced BMCS integration for IEQ.
- Understanding the drivers of peak electrical demand and the relationship between demand response and comfort.
- The water/energy nexus in HVAC&R.
- Practical applications of natural refrigerants within the built environment.
- Strategies, incentives and education of optimisation techniques for the upgrade of existing HVAC in buildings.
- Disseminate research findings while encouraging discussion and debate.
- Provide a platform for collaboration either through a research seminar/conference or through an Australian HVAC&R multi-institute research centre or foundation.
- Assist researchers with recruiting the people, buildings and field sites necessary as research subjects for various research programs.
- Co-supervision of postgraduate research projects.
- Liaise with government to advocate for funding to be delivered for applied research and not just fundamental research.
- Advocate for a fair share of the ARC (Australian Research Council) funding allocations (see information page on ARC).
- Increase visibility to students (e.g. by sponsoring an AIRAH student prize).
- Assist with the peer review of research papers and research program plans.

There is no doubt that there is a significant role for AIRAH in the HVAC&R research space.

WHAT DOES THE HVAC&R INDUSTRY WANT FROM RESEARCHERS?

The industry PRIME initiative being facilitated by AIRAH includes some of the goals and aspirations that industry has for HVAC&R-related research.

WHAT IS THE ARC AND WHY DO WE CARE?

The Australian Research Council (ARC) is a statutory agency within the Australian government's Industry, Innovation, Climate Change, Science, Research and Tertiary Education portfolio.

The ARC Discovery programs fund individual researchers and projects. The ARC Linkage programs help to broker partnerships between researchers and industry, government and community organisations, as well as the international community.

AIRAH'S ROLE IN THE RESEARCH SPACE

The survey also asked researchers what they thought AIRAH's role should be in the research space. Nobody proposed that AIRAH should start undertaking research activities but there were some suggestions that sourcing funding, and in-kind support, may be an appropriate role. There is an overwhelming consensus that AIRAH should act as a facilitator, a bridge between academia and industry. Some of the activities proposed for AIRAH include:

- Identify the key HVAC&R industry research needs and match these to institution research capacity.
- Facilitate collaboration between researchers and industry, and between different research groups; an interface between industry and researchers.
- Develop a research roadmap for the HVAC&R industry.

ARC-funded projects in the field of ventilation, refrigeration and air conditioning, 2007 to 2012.

ARC Discovery projects	
Year	Project
2011	"Cool living heritage in Southeast Asia: sustainable alternatives to air-conditioned cities" – \$195k over three years led by Dr Tim Winter from University of Western Sydney.
2010	"Field survey of residential air conditioning and comfort in Australia" – \$116k over three years led by Prof Richard De Dear from University of Sydney. "Designed magnetocaloric materials – cooling for the future" – \$130k over three years led by Prof Stewart Campbell from University of New South Wales.
2008	"Radiative Cooling Tuned to the Spectral and Directional Infra-red Properties of the Atmosphere" \$270k over three years led by Prof BG Smith from University of Technology Sydney.
2007	"Occupant comfort in naturally ventilated and mixed-mode spaces within air-conditioned offices" – \$129k over three years led by A/Prof Richard De Dear from Macquarie University. "Giant Magnetocaloric Materials and Room Temperature Refrigeration" – \$760k over four years led by Prof SX Dou from University of Wollongong.
ARC Linkage projects	
2012	"Green cool wine: solar powered solid adsorption refrigeration system with ice storage to provide cooling capability for wine industry" \$195k over four years led by A/Prof Eric Hu from University of Adelaide.
2010	"Developing an integrated predictive model for optimal design of ventilation systems in buildings" \$246k over three years led by Prof JY Tu from RMIT University.
2009	"Impact and Effectiveness of Personal Ventilation in Open Plan Offices: a study of the Task Air system" \$80k over three years led by Dr Scott Drake from University of Melbourne.
2008	"Characterisation of Wood Dust Exposures and Its Effects on Respiratory Health" \$235k over three years led by Prof JY Tu from RMIT University.
2007	"Residential Air Conditioning, Comfort and Demand Response in Australia" \$235k over three years led by A/Prof R De Dear from Macquarie University. "Novel methods for enhancing room temperature figure of merit of thermoelectric/thermionic materials for refrigeration applications" \$247k over three years led by Prof C Zhang from University of Wollongong.
<p>Summary:</p> <ul style="list-style-type: none"> • ARC Discovery projects – a total funding of \$1.6M over six years or approximately \$270k funding per year. • ARC Linkage projects – a total funding of \$1.2M over six years or approximately \$210k funding per year. <p>Note: Grants from the ARC are made to organisations, not individual researchers or research teams.</p>	

Industry wants researchers to provide a pathway to market for new and rediscovered low-emission technologies. Industry wants evidence-based performance assessment of HVAC&R innovations, and evaluation of the energy-efficiency characteristics of new technologies and practices, including passive techniques. What is needed is the creation of new and robust practical links between industry and academia.

In order to validate some of the PRIME initiatives, industry also wants researchers to provide solid, trusted, life-cycle-based benefit/cost analysis for:

- The maintenance value proposition, documented energy savings from proactive energy-efficiency maintenance.
- The hidden energy costs of refrigerant charge leakage, how inefficient are undercharged systems.

- Leak detection and containment strategies, practices and technologies.
- The hidden value in decommissioned HVAC&R plant and equipment.

As can be seen, there is plenty of common ground and the future bodes well for greater collaboration between researchers and the HVAC&R industry. ■