ARENA INSIGHTS SPOTLIGHT: THE AFFORDABLE HEATING AND COOLING INNOVATION HUB (I-HUB)

AN INTERVIEW WITH THE AUSTRALIAN INSTITUTE OF REFRIGERATION, AIRONDITIONING AND HEATING (AIRAH)

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Australian Renewable Energy Agency

ARENA

INTRODUCTION

The Australian heating, ventilation, air-conditioning and refrigeration (HVAC&R) sector consumes around 22 per cent of all electricity produced and is responsible for around 50 per cent of peak demand on the electricity grid. This is a substantial energy-consuming sector that provides a largely untapped opportunity for enhanced grid-interactive control of demand response, load flexibility, renewable energy uptake and integration of various technologies.

ARENA has co-funded the Affordable Heating and Cooling Innovation Hub (i-Hub) project, led by the Australian Institute of Refrigeration Air Conditioning and Heating (AIRAH), to demonstrate how renewable energy technology can be optimally integrated with HVAC&R equipment in commercial buildings.

INTERVIEW WITH:

VINCENT AHERNE
PROJECT LEADER, I-HUB PROJECT

I-HUB PROJECT

ARENA: WHAT HAVE BEEN THE MAIN AREAS OF FOCUS FOR I-HUB AND WHY?

The i-Hub project comprises 32 individual sub-projects, which have been distilled into 3 Activity Streams:

The **Living Laboratories** activity includes the establishment of 4 living laboratories (one Hospital, two Aged Care facilities and two School sites) and 2 sector-wide analysis projects. Healthcare and Education buildings have been a focus for i-Hub due to their intensive energy use profiles and their tendency to be owned in large portfolios. Living Laboratories establish research-quality measurement and verification systems within existing buildings in order to observe and evaluate technology upgrades within the context of the daily operation of these buildings. This is different from 'normal' laboratory testing which is often undertaken under standardised (and most commonly steady-state) conditions and does not address occupant needs and system interactions with the building.

The **Integrated Design Studio** activity focuses on running a series of Integrated Design Studios, bringing architectural and engineering design together for a range of building and owner types and putting renewable energy and net zero outcomes at the core of the design process. Each design studio is facilitated by a university, bringing owners and designers together in a 'neutral' design environment and leveraging academics and university students to generate and evaluate innovative design solutions, all the while studying the barriers and enablers of a successful integrated design process.

The **Data Clearing House** (DCH) activity focuses on developing, testing and refining a new open-access digital 'Data Institute' for buildings, where building owners can connect their smart buildings and use a range of innovative energy-based applications to reduce the cost (and emissions) of building operation and optimise their energy assets. A major focus of the DCH activity is optimising a building's energy and HVAC assets, minimising operational energy use, and exploring opportunities for connected buildings to participate in flexible demand markets.

ARENA: WHAT ARE THE MAIN OUTCOMES YOU SEE COMING FROM THIS PROJECT?

The main outcomes coming from the i-Hub Project will be:

- Establishment and legacy of 4 Living Laboratories where industry can test innovative decarbonisation technologies and services in a fully instrumented real world occupied building.
- Development of a Renewable Energy and Enabling Technology and Services Roadmap for Healthcare/Education, showing the benefits and impacts of the potential widespread application of technologies assessed in the Living Laboratories.
- Establishment of an industry-run Data Clearing House platform, offering new data sharing and control strategies that will enable automated participation in demand response markets, efficient and productive HVAC operation, optimised renewable generation and energy storage assets, and improved cyber security data control, building/system connectivity and digital interoperability.
- Increased availability of demand response with specific identification of 100 MW of potential within the broader i-Hub portfolio.
- Increased understanding of methods to reduce peak demand and demand charges as well as increase the hosting capacity of solar through HVAC load control combined with onsite renewable energy control.
- New Integrated Design Studio approach showcasing the benefits of co-design delivering lower cost and higher performance buildings.
- Identification of design, digital and technological solutions to reduce onsite energy use by at least 25 per cent compared to business as usual.

Achieving these outcomes relies on sharing the information and tools we have developed with the HVAC industry and relevant industry sectors. Knowledge Sharing has been a major focus of the i-Hub Project and i-Hub has delivered a range of knowledge sharing summits and an integrated design symposium as well as documenting a series of technical reports and lessons learnt from individual project teams. All the knowledge sharing collateral developed by i-Hub to date is available at The Knowledge Hub - iHub

I-HUB DATA CLEARING HOUSE ACTIVITY

ARENA: HOW CAN DATA PLATFORMS BE USED TO DELIVER ENERGY SAVINGS?

Data platforms provide the cloud-computing services (storage, database management, software and algorithms) necessary to consolidate diverse data sources in one place, run real-time data-driven analytics and automate processes through machine-to-machine connectivity.

They provide the underpinning infrastructure for building owners to simply access information on the operation of their buildings through their web-browser – so that they can benchmark performance and make more informed decisions.

They enable access to new data sources to help identify patterns in energy consumption behaviour. For example, this can be used to detect faulty equipment operational settings that waste energy. A large-scale international study showed that this alone saves around 9 per cent on building energy consumption.

They enable dynamic HVAC control strategies that are responsive to weather and to external market signals such as calls for flexible demand. The NSW Government's HVAC Optimisation Guide provides examples of a variety of advanced control strategies that can be implemented, with energy savings ranging from 5 to 30 per cent.

Ultimately data platforms allow the building's energy demands and energy assets to be integrated and managed in real-time to optimise the use of renewable energy, reduce building emissions and reduce the cost of heating and cooling.

ARENA: HOW CAN BUILDINGS SHIFT THEIR ENERGY CONSUMPTION AND MAKE THEIR USE OF ENERGY MORE FLEXIBLE? AND WHY IS THAT VALUABLE?

Buildings have significant thermal storage that can act like a battery to balance the supply and demand for energy. This flexibility includes the inherent thermal mass embedded in building structures, the thermal storage in hot water systems and the potential to add additional thermal storage to air conditioning systems.

From an energy system perspective, the US Department of Energy identifies the need for 'Grid-Interactive Efficient Buildings' to simultaneously take advantage of both energy efficiency and demand flexibility. They claim that over the next two decades, GEBs could save the US power system USD 100-200 billion and help reduce power sector CO2 emissions by around 6 per cent. Similarly, IEA scenario modelling expects around 50 per cent of required flexible demand capacity will come from buildings.

At a site level, building owners can reduce energy bills - both by reducing energy consumption and shifting consumption to when energy is cheapest, such as when renewable sources like wind and solar are operating. At the Newcastle Steel River Energy Centre, the Data Clearing House is being used to forecast site load and provide an optimal daily schedule for equipment operation. This is saving 6 per cent on energy bills, mainly through reduction in peak demand tariffs. In another example, the Exergenics exOptima software is using data from the Data Clearing House to optimise chiller staging. This has provided initial savings of 4.3 per cent in its first month of field testing and is predicted to reduce peak demand by around 18 per cent.

ARENA: HOW MUCH FLEXIBLE DEMAND COULD WE EXPECT TO GET FROM NON-RESIDENTIAL BUILDINGS AND WHAT IS THAT WORTH TO AUSTRALIAN CONSUMERS?

We have done top-down and some bottom-up modelling of what might be available.

From a top-down perspective, we looked at the temperature (weather) dependent component of electricity network demand – the component which is dominated by air conditioning loads. We estimate that there is around 8.4GW of air conditioning load on hot days (6.9GW residential, 1.5GW non-residential). This load (around 26 per cent of NEM peak summer demand) could be a huge resource in an emergency event. Literature studies suggest that around 25 per cent of this could also be suitable as a flexible demand resource with minimal (if any) impact on occupant comfort.

The RACE for 2030 Cooperative Research Centre found that 1 GW of flexible demand could save around $300million/year in electricity supply costs, through reduced wholesale market volatility, reduced network infrastructure costs and emergency services. Air conditioning alone could provide this level of flexibility, reducing electricity costs for all consumers.

ARENA: WHAT CHALLENGES ARE EXPERIENCED BY BUILDING OWNERS WHO WOULD LIKE TO SELL THEIR FLEXIBLE DEMAND RESOURCE AND HOW IS THE DATA CLEARING HOUSE HELPING TO ADDRESS THIS?

Industry stakeholders have identified barriers relating to device interoperability, data quality, complexity, workforce skills and inadequate IT infrastructure and connectivity. The Data Clearing House is looking to provide a standardised IT infrastructure and connectivity solution that streamlines access to data for the whole industry. In doing so, it is supporting data standards and data governance principles that drive improved data quality and reduced complexity.

The Data Clearing House philosophy is that the first step on the journey is to get the building "digital ready" with the necessary basic IT infrastructure and connectivity. From there, the cost of onboarding additional services can be a fraction of the cost compared with treating every service as a bespoke siloed offering.

The Data Clearing House is aiming to solve the challenge of enabling software to understand the workings of a building without human intervention. The design and construction industry is proud that "every building is a prototype," but the challenge for scaling energy analytics software is to enable it to be deployed in a self-serve way - analogous to downloading Apps on a smartphone.

ARENA: HOW WILL THE DATA CLEARING HOUSE DEVELOPMENT BE USED GOING FORWARD?

The Data Clearing House will be used for a range of industry and research purposes. Several companies have approached CSIRO to explore how they can deploy services on the platform.

We will also look to support public-good data collection to help provide a source of anonymised data that can be used to benchmark HVAC equipment performance and support development of innovative artificial intelligence algorithms. For example, the Data Clearing House has been selected as a platform for hosting data-driven building-services competitions for a consortium of European industry and research partners. The ADREANALIN consortium is funded under the ERAnet "Digital Transformation for Green Energy Transition" program.

I-HUB INTEGRATED DESIGN STUDIO ACTIVITY

ARENA: WHAT IS THE MAIN FOCUS OF THE INTEGRATED DESIGN STUDIO ACTIVITY?

The Integrated Design Studio activity has two principal areas of focus.

The first is on how to better facilitate Integrated Design, particularly relationships and interactions between architects and engineers. These relationships are often not well developed in current practice, despite best intentions to do so. It is imperative, given the large energy consumption attributable to our built environment, that our designs deliver better technically performing buildings and infrastructure. Good theoretical knowledge exists in this respect, we have been testing this practically in real design environments and have learned a lot in the process.

The second area is on zero carbon design. Given the i-Hub focus on renewable energy, designing net zero carbon buildings is a natural case study to use in examining how architects and engineers work together. Through the various design studios run with consultants from industry we have a pool of knowledge and appropriate 'design moves' that can be made in different building typologies to try and get to zero carbon outcomes. Building types range from schools through laboratories and aquatic centres to transportation buildings.

ARENA: HOW CAN INTEGRATED DESIGN CONTRIBUTE IN DELIVERING LOWER COST AND HIGHER PERFORMANCE BUILDINGS?

One of the main tenets of Integrated Design is to embrace multi-functionality of design elements, which reduces cost by having building elements do more than one thing at a time. For example, the architecture can incorporate renewable sources of energy such as photovoltaics, that also provide shade or protective cladding, or elements of exposed thermal mass that are interesting architecturally and add to the space quality, while they also mediate daily fluctuations in internal temperature.

In addition to this, the ethos of Integrated Design involves bringing all project stakeholders to the table for design. This includes the client, user groups, designers, quantity surveyors, construction professionals and many other team members. Every aspect of design is given a hearing and optimised/integrated for technical performance but also for cost, ease of maintenance, effectiveness of internal function etc.

ARENA: WHAT ARE THE KEY BARRIERS AND LESSONS LEARNT IN FACILITATING INTEGRATED DESIGN ON PROJECTS?

The key challenges and lessons learnt related to an Integrated Design approach have been summarised below:

- **Procurement methods and fees** – These are generally set up to encourage designers to minimise up-front time on projects, to maximise margins and allow a contingency to fix issues during construction. However, the value of Integrated Design often overcomes the time and money issues - "The whole can be greater than the sum of the parts".
- **Mindset** – Current design mindsets can be very inward focused instead of including an understanding of the bigger picture. The Integrated Design process needs to be flexible and bespoke to allow contribution of different players. Designers need to understand the value others bring and be prepared to compromise or adjust their work towards bigger picture solutions, rather than staying within the safety of their own single disciplines in which they have more control and understanding.
- **Senior experience applied early on** – Often the experience on projects comes from junior staff focused on sorting out contracts and administration, with design coming in as a second priority. Integrated Design requires the involvement of experienced staff with strong design knowledge very early on in the design process.
- **Lack of big picture view** – Designers have no choice but to view the design from within the design team. i-Hub found that having an independent third party curating the design process was extremely beneficial. This third party had carriage of the overall process and design direction and was responsible for making sure different stakeholders input was provided and included at the appropriate time.

We have produced and are periodically updating a "Catalyst for Integrated Design" document that will encapsulate the lessons learned and provide guidance to industry on how to best facilitate integrated design on projects.

I-HUB LIVING LABORATORY ACTIVITY

ARENA: WHAT TYPE OF NEW TECHNOLOGIES TESTED BY I-HUB LIVING LABORATORIES CAN CONTRIBUTE TO THE DECARBONISATION OF COMMERCIAL BUILDINGS OVER THE NEXT DECADE?

In general terms, the technologies tested in the 4 Living Labs can be placed into one of four categories:

1. technologies that implement predictive demand responsive control of HVAC equipment integrated with existing AEMO demand response market mechanisms. Examples of these technologies are controllers that connect directly to the utility meter and enable the trading of consumption, generation and demand response on the AEMO wholesale and RERT markets.
2. technologies that enhance the thermal performance of the building envelope. Examples of these technologies are high performance thermal envelope transportable buildings, and cellular honeycomb shade devices providing both insulation and shade to a window.
3. technologies that enhance the energy efficiency or operation of strategies for providing indoor environment conditions. Examples of these technologies are chiller system digital twin and optimisation technologies and digital twinning technologies for building HVAC.
4. technologies that relate to renewable energy, electrification, energy storage or energy management at a site level. Examples of these technologies are control systems that optimise the effectiveness of the PV – Battery – HVAC control – energy recovery ventilation (ERV) nexus.

These categories relate to the prime strategies for decarbonising buildings: improving the generation-demand grid stability balance and cost performance at the major source of peak demand (HVAC); avoiding energy use through better buildings; improving the efficiency and operation of equipment; and using low or zero carbon energy sources.

ARENA: WHAT IS A RENEWABLE ENERGY AND ENABLING TECHNOLOGY AND SERVICES EVALUATION FRAMEWORK (REETSEF), AND WILL THAT ANALYSIS FEATURE IN THE SECTOR-WIDE ROADMAPS FOR HEALTHCARE AND EDUCATION SECTORS?

The REETSEFs are the frameworks used to describe the general conditions considered for the establishment and operation of the three healthcare living laboratories and the education living laboratory. Their focus was on defining potential key performance indicators and establishing the measurement and verification techniques and data analysis methodologies, as well as defining the technology selection process.

The Roadmap will draw on all of the activities undertaken in the living lab projects (technology evaluations as well as sector-wide activities), in order to present a guidance document and checklist to assist organisations to develop a bespoke renewable energy and enabling technologies plan for individual buildings or sets of assets in their portfolios. The main avenue for broad utilisation and uptake of the Framework, Roadmap and emerging technologies will be the Renewable Energy Knowledge Sharing Task-Groups for Healthcare and Education, established for this purpose.

Further information is available at
arena.gov.au

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